Annual Convention to be held in Hartford, Conn., week of September 10, 1917.

Volume 31. MARCH, 1917. $3.00 a Year.
Number 1. $1.00 a Number.

JOURNAL

OF THE

New England Water Works Association.

ISSUED QUARTERLY.

PUBLISHED BY

THE NEW ENGLAND WATER WORKS ASSOCIATION,

715 Tremont Temple, Boston, Mass.

Entered as second-class matter September 23, 1903, at the Post Office at Boston, Mass., under Act of Congress of March 3, 1879.

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OF THE

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1917.

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A. E. PICKUP, Water Registrar, City of Holyoke, Mass.
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THE ASSOCIATION was organized in Boston, Mass., on June 21, 1882, with the object of providing its members with means of social intercourse and for the exchange of knowledge pertaining to the construction and management of water works. From an original membership of only TWENTY-SEVEN, its growth has prospered until now it includes the names of over **1 000** men. Its membership is divided into two principal classes, viz.: MEMBERS and ASSOCIATES. Members are divided into two classes, viz.: RESIDENT and NON-RESIDENT, — the former comprising those residing within the limits of New England, while the latter class includes those residing elsewhere. The INITIATION fee for the former class is FIVE dollars; for the latter, THREE dollars. The annual dues for both classes of Active membership are THREE dollars. Associate membership is open to firms or agents of firms engaged in dealing in water-works supplies. The initiation fee for ASSOCIATE membership is TEN dollars, and the annual dues FIFTEEN dollars. This Association has six regular meetings each year, all of which, except the annual convention in September, are held at Boston.

CALEB MILLS SAVILLE,

President New England Water Works Association,

1917.

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New England Water Works Association.

ORGANIZED 1882.

Vol. XXXI. March, 1917. No. 1.

This Association, as a body, is not responsible for the statements or opinions of any of its members.

REPORT OF COMMITTEE ON DEXTER BRACKETT MEMORIAL.

[*Read September 13, 1916.*]

BOSTON, September 1, 1916.

TO THE NEW ENGLAND WATER WORKS ASSOCIATION:

The Committee on Dexter Brackett Memorial submits its final report, accompanied by the medal which has been designed for it, and a draft of rules for its award.

History of the Memorial. At the convention of 1915, a committee was appointed to consider the practicability of establishing a memorial to Past-President Dexter Brackett, and the most suitable form of such memorial. In November, 1915, that committee reported recommending that such a memorial be established, and that it take the form of a bronze medal to be awarded annually for a meritorious paper; that it would cost a little more than one thousand dollars to establish such a medal, and that a comparatively few members had subscribed to a guaranty fund of nearly nine hundred dollars, thus insuring the success of such an enterprise.

The Association thereupon voted that a committee should be appointed to obtain subscriptions, procure designs for a medal and have dies prepared, and draft rules for the annual award. The present committee was appointed pursuant to that vote.

Organization and Work of the Committee. The committee organized with Frederic P. Stearns as chairman and Charles W. Sherman as secretary and treasurer. It has held but few formal meetings, most of its work having been accomplished by correspondence and by informal conferences.

Subscriptions. An opportunity to subscribe to the fund was presented to the entire membership of the Association, as it was felt that many who could not afford to make large contributions would wish to give something. It was made clear that the guaranty fund assured the success of the memorial, and that no one was expected to contribute unless he felt a personal interest in the matter, or a larger sum than he could well afford. The total amount received was $1 281.50, from 101 contributors; of this, $870 was received from 33 subscribers to the guaranty fund. The names of the subscribers are contained in an appendix to this report. (Appendix A.)

Design. Immediately after its organization, the committee began to inform itself about work of this character, and soon selected Mr. Theodore Spicer-Simson, of New York City, an artist of international reputation in the design of medals, as the designer of the Brackett Memorial. From its purpose it was obvious that one side of the medal should bear a portrait of Mr. Brackett, and the other a design typical of the Association and an inscription indicating the purpose of the award, the name of the recipient, and the date. Mr. Spicer-Simson has produced the medal presented at this time, photographs of which are attached to this report for record.

Rules for Award. The committee has devoted much thought to suitable rules for the award of the medal, and has prepared a draft of rules, which it submits herewith as Appendix B.

Fund to Provide for Payment for Medals and Cases. It was the desire of the committee that the establishment and maintenance of this memorial should not involve any draft upon the funds of the Association, and the contributions received have been sufficient to accomplish that result. After paying all its expenses, the committee has remaining the sum of $197.34, which is turned over to the Association herewith. This sum, if kept as a fund, would produce an income approximately sufficient to pay the annual cost of the medal and case, and engraving. We do not recommend that this sum be kept as a fund, but that, in consideration of its receipt, the Association assume the obligation of annually furnishing a medal and case, with suitable marking.

PLATE I.

N. E. W. W. ASSOCIATION.

VOL. XXXI.

REPORT OF COMMITTEE ON DEXTER BRACKETT MEMORIAL.

Receipts and Expenditures. As stated above, the committee has received subscriptions to the amount of $1 281.50, and interest on bank balances has amounted to $5.14, making a total of $1 286.64. The expenditures have been —

For design of medal and construction of dies	$1 000.00
For 11 medals for N. E. W. W. A.	22.00
For proof copy of medal, with case, for Mrs. Brackett,	5.25
Committee expenses, — stationery, printing, postage, express, etc.	62.05
Total	$1 089.30
Balance	$197.34

which, as stated above, is now transmitted to the Association as approximately the capitalized cost of striking off and engraving medals and furnishing cases.

Respectfully submitted,

FREDERIC P. STEARNS,
ALLEN HAZEN,
ALFRED D. FLINN,
GEORGE A. STACY,
CHARLES W. SHERMAN,
Committee.

This report was accepted by vote of the Association on September 13, 1916 (xxx, 493).

At the meetings of the Executive Committee on January 10 and 29, 1917, the following gentlemen were chosen as the Committee on Award: Desmond FitzGerald, M. N. Baker, A. E. Martin.

APPENDIX A.

Contributors to the Dexter Brackett Memorial.

*Allardice, E. R. B.

Barbour, F. A.
Barrows, H. K.
Bell, D. V.
Bemis, E. W.
Benzenburg, G. H.
Booth, G. W.
Brooks, E. C.
Brown, A. W. F.
Bryant, H. F.
Burnie, James

Chase, J. C.
Clarke, D. D.
*Coggeshall, R. C. P.
Columbian Iron Works
*Conard, W. R.
*Connet, F. N.

*Davis, J. P.
Doane, A. O.
Dockweiler, J. H.
Doherty, M. J.
Dunn, L. F.
Dwyer, T. E.

Earl, G. G.
*Eddy, H. P.
Eglee, C. H.

Fay, F. H.
Ferguson, S. F.
*FitzGerald, Desmond
*Flinn, A. D.
*Forbes, F. F.
*Foss, W. E.
*Freeman, J. R.
Frost, G. H.
Fuller, F. L.
Fuller, G. W.

Gilchrist, G. E., Co.
*Glover, A. S.
*Goodnough, X. H.
*Gould, J. A.

*Haberstroh, C. E.
Hale, R. A.
Harrison, Samuel
Hathaway, A. R.
Hazard, T. G., Jr.
*Hazen, Allen
Heffernan, D. A.
Hill, A. B.
Hill, N. S., Jr.
Houdlette, F. A., & Son
*Howard, J. L.
*Howe, E. W.

Kent, Willard
*Killam, S. E.
Kimball, F. C.
King, G. A.
*Knowles, Morris

Lea, R. S.
Lochridge, E. E.
Looney, E. J.

Main, C. T.
Martin, A. E.
Maury, D. H.
Mayo, John
Merritt & Chapman Derrick & Wrecking Co.
*Metcalf, Leonard
Miller, H. A.
*Mills, H. F.
Moran, J. W.
Mueller, H., Mfg. Co.

Porter, Dwight

Quinn, E. W.

Ridgway, Robert
Robinson, L. C.

*Sando, W. J.
*Saville, C. M.
*Sherman, C. W.
Sherrerd, M. R.
Smith, A. P., Mfg. Co.
*Smith, J. W.
Spofford, C. M.
Stacy, G. A.
*Stearns, F. P.
Stearns, R. H.
Sullivan, W. F.
Swain, G. F.

Taylor, W. P., Co.
Tighe, J. L.
*Tilden, J. A.
*Tinkham, S. E.
Tower, D. N.

United States Cast Iron Pipe and Foundry Co.

Walsh, J. H.
*Weston, R. S.
Wheeler, William
*Whipple, G. C.
Wilkins, F. B.
Williams, G. S.
*Winslow, F. I.
Wood, Walter
*Woods, H. D.

33 guarantors; 101 contributors.

*Contributors to the guaranty fund.

APPENDIX B.

Suggested Rules Governing the Award of the Dexter Brackett Memorial Medal.

The Dexter Brackett Memorial has been established by contributions to perpetuate the memory of Dexter Brackett, who was president of the Association for the year 1889–1890.

In consideration of the donation of the dies and an accompanying fund, the Association has assumed the responsibility for the payment in perpetuity for the Dexter Brackett Memorial Medal.

Committee on Award.

1. The Executive Committee shall annually appoint three members of the Association who shall constitute a committee to recommend the award of the Dexter Brackett Memorial Medal for the preceding year. This appointment shall be made not later than the regular meeting in February. Members of the Executive Committee shall not be eligible for appointment upon the Committee on Award, nor shall the author of any paper which is to be considered by the committee.

2. The papers to be considered shall include all papers written by members of the Association and published in the volume of its Journal for the calendar year for which award is to be made.

3. The committee shall report its recommendations to the Executive Committee on or before August 1, and the award shall be made by the Executive Committee. The announcement of the award and presentation of the medal shall be made at the annual convention.

Rules for Award.

1. Competition for the medal shall be restricted to members of the New England Water Works Association.

2. There shall be one bronze medal awarded annually, unless, in the opinion of the Committee on Award, no paper shall have been published of sufficient merit to receive the award.

3. Any original paper presented to the Association by a member, and published in the volume of the Journal for the calendar year for which the medal is to be awarded, shall be open to the award, provided that such paper, or an important part thereof, shall not have been previously contributed to any other society, nor have appeared in print prior to its presentation to the Association, nor have been published in the Journal in any previous year.

4. The medal shall be awarded for the paper which is judged to be most meritorious, bearing in mind its applicability to general water-works problems.

REPORT OF COMMITTEE ON GRADING WATER WORKS WITH REFERENCE TO THEIR VALUE FOR FIRE PROTECTION.

[*Presented September 15, 1916.*]

Necessity for Grading of Cities.

It is obvious that in any attempt to equitably fix fire insurance rates, some scheme of classifying or grading of cities must be adopted, in which all features which affect liability to fires and the facilities for extinguishing them should be taken into account.

In the past, methods of grading for insurance purposes seem to have been of a haphazard character, at least in so far as water works were concerned, and it has been impossible to obtain any definite information which would enable one to judge in advance what modifications in grading would result from establishing, or from a radical improvement of, a water-works system. It has therefore been impossible, as a rule, for water-works engineers or superintendents to indicate what saving in insurance premiums might be expected as the result of any particular improvement in fire protection resulting from improved water works.

It is obvious that the formulation or adoption of a system of grading will not of itself adjust insurance rates. These rates are established by local boards or commissions, not all of which base their grading upon the same subdivisions into groups or classes, and of course the rates fixed in various districts are often widely divergent. The adoption of a scientific uniform scheme of grading is nevertheless the first step towards a systematic and scientific scheme of establishing rates, and after the adoption of a standard scheme of grading, it would be possible to estimate what improvement in grading would result from any contemplated change in the water-works system and thus compute, at least approximately, what saving in insurance rates can be obtained in view of the rates locally in force.

Grading Schedule Proposed by National Board of Fire Underwriters, 1915.

The first attempt at a scientific schedule for grading cities and towns with reference to fire defense and physical conditions was prepared by the engineers of the National Board of Fire Underwriters in 1915. This was done as a necessary preliminary to the attempt of the actuarial bureau of that Board to classify fire losses and from the study of data thus obtained to establish a basis of scientifically fixing insurance rates.

The grading schedule proposed by the National Board is based on several years of careful investigation by their engineering staff, of the fire protective features of cities throughout the United States. It is based upon a plan of assigning to the various features of fire defense, points of deficiency depending upon the extent of variance from standards formulated by a study of conditions in more than five hundred cities, the natural and structural conditions which increase the general hazard of cities, and the lack of laws or of their enforcement for the control of unsatisfactory conditions. The sum of the maximum points of deficiency is 5 000, divided in accordance with the relative features considered, as fixed by the engineers of the National Board, as follows:

Relative Values.

		Points.	
Water supply	Engine stream basis		1 700
	Hose stream basis	2 000	
Fire department	Engine stream basis		1 450
	Hose stream basis	1 150	
Fire alarm		550	
Police		50	
Building laws		200	
Explosives and inflammables		200	
Electricity		150	
Natural and structural conditions		700	
	Total,	5 000	

The classification based on this schedule is as follows:

A 1st Class	City or Town is one receiving from 0 to		500	points of deficiency.
A 2d	do.	do.	501 to 1 000	do.
A 3d	do.	do.	1 001 to 1 500	do.
A 4th	do.	do.	1 501 to 2 000	do.
A 5th	do.	do.	2 001 to 2 500	do.
A 6th	do.	do.	2 501 to 3 000	do.
A 7th	do.	do.	3 001 to 3 500	do.
An 8th	do.	do.	3 501 to 4 000	do.
A 9th	do.	do.	4 001 to 4 500	do.
A 10th	do.	do.	more than 4 500	points, or without any fire protection.

The detailed schedule in its present form is appended to this report as far as it relates to water-works features. Trial applications of the schedule have been made by the engineers of the National Board to about two hundred cities and towns of various sizes in different parts of the country; as a result, some changes and additions have been made, mostly in the nature of amplifications. It is probable that, in years to come, experience will show further revision of like nature to be desirable.

Reasons for Interest in Insurance Grading on Behalf of the New England Water Works Association.

It may be that some question will arise as to the propriety or desirability of the New England Water Works Association interesting itself in a matter which, on the face of it, has to do only with the grading of cities for insurance purposes. The manner in which water-works men may utilize schedules for grading has already been suggested. It must not be forgotten, too, that the engineers of the insurance companies are as a rule hydraulic or water-works engineers who are devoting themselves to advising their employers, the insurance companies, with relation to the efficiency for fire fighting of the water-works systems, so many of which are in the control of members of this Association. To be sure, the insurance engineer studies also the effect of many other features upon fire hazards and fire protection, but almost all of them have to do with the facilities for quickly and advantageously utilizing the protection afforded by our water-works systems.

It is obviously desirable, therefore, that the engineers grading these systems with a view to their value for fire protection, and the men in control of the water works, should agree as to the methods and points by which rating shall be arrived at. Constructive criticism on a standard grading schedule should therefore be obtained, not alone from the engineers engaged in making such rating, but also from the men having to do with the construction, operation, and maintenance of our water-works systems.

With this idea in view the New England Water Works Association passed a vote in February, 1916, authorizing the appointment of the present committee.

Progress Report of Committee.

This committee wishes at the outset to call attention to the notably friendly spirit manifested by the National Board of Fire Underwriters, which has welcomed our criticism and has coöperated with us in every way, sending its chief engineer, Mr. George W. Booth, and his principal assistant, Mr. Clarence Goldsmith, both of whom are members of this Association, to confer with us in Boston. In short, the National Board has shown an open and above-board policy, and a willingness to recognize the New England Water Works Association, and the assistance which it could afford, that augurs well for a better future understanding between the water-works and the insurance interests.

The committee has given the proposed schedule careful study, and, considering it as a whole, is satisfied that it is a long step in the right direction. Until the committee has had opportunity to study the results of the application of the schedule to systems with which its members are familiar, criticisms of the detail, and particularly of the number of points of deficiency assigned to various features, are not of controlling significance at the present time. The classification, when effected, will in the nature of things have a direct bearing upon the actual insurance rates, particularly when studied in connection with the data relating to actual losses now being classified and arranged by the actuarial committee of the National Board. It is inconceivable that the rates should continue to be assessed in the present illogical and

oft-times unfair manner. The practical and most desirable result fairly to be expected to follow the adoption of the schedule, as was noted above, is the possibility of determining with reasonable accuracy the saving in insurance that will result from a given expenditure for improvements in a water-works system. In other words, it will be possible in designing a new system or improving an old one to estimate upon probable insurance rates, just as comparative construction costs are now figured.

In the meetings of the committee considerable criticism developed in regard to certain fundamental provisions of the schedule. After full and free discussion with the engineers of the National Board, we found that many of the questions raised by us were the same as those which they had met and discussed in their earlier study of the problem, and we are now satisfied that the schedule in its present form is a well-considered one.

Certain modifications have been made at our suggestion, and others are now under consideration. In two respects, however, we have been unable thus far to fully agree with the engineers of the National Board or to convince them of the equity, from their point of view as well as of ours, of certain changes which it seems to us should be made. First, no penalty is assigned to too frequent or unduly large fire pipe connections from distribution systems, nor are rules which should obtain in regard to the granting of such connections considered in the schedule. We fully recognize the imperative need of connections of sufficient size for fire defense, but we equally recognize the necessity of adequately safeguarding them. Water in our mains should be used for fire protection just as poisons are used in medical practice: to cure and not to kill the patient.

The second issue is in regard to the right to existence of the so-called 4-in. hydrant. As submitted to us, the grading schedule would penalize this hydrant under all conditions, since none of the 4-in. hydrants can meet the stipulations as to capacity and friction loss. We fully recognize that the 4-in. hydrant has no place in urban conditions, but we are unable to agree that the same is true under all conditions, and we feel that the logical course is to recognize that the small hydrant, like the smaller sizes of pipe, has its proper sphere. The 4-in. hydrant should be

severely penalized in city practice; but in districts where the pipes are properly small and where the necessity of anything more than a single comparatively small fire stream is practically non-existent, we believe that no deficiency should be charged on account of the use of the 4-in. hydrant.

Recommendations.

The vote under which this committee was established instructed it to report whether or not it was desirable for the Association to indorse this or any similar schedule. Your committee is fully in accord with the principle of the schedule under consideration, but does not think it wise nor desirable to pass any vote of endorsement at the present time, in advance of its final adoption by the National Board, and in view of possible slight modifications before it reaches its final form. No action of the Association is therefore recommended at the present time. It is believed, however, that members of the Association confronted with problems of this nature will be materially assisted by the schedule, even in its preliminary form, and that coöperation with the engineers of the National Board will result in further perfecting it.

The above is presented as a report of progress.

Respectfully submitted,

F. A. McInnes,
C. M. Saville,
Henry V. Macksey,
R. J. Thomas,
Charles W. Sherman,
Committee.

August 23, 1916.

APPENDIX.

PROPOSED STANDARD SCHEDULE FOR GRADING CITIES AND TOWNS OF THE UNITED STATES WITH REFERENCE TO THEIR FIRE DEFENSES AND PHYSICAL CONDITIONS.

NATIONAL BOARD OF FIRE UNDERWRITERS, NEW YORK, 1915.

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INTRODUCTORY.

The Grading Schedule is based upon the plan of assigning to the various features of fire defense found in cities of the United States, points of deficiency depending upon the extent of variance from standards formulated from a study of conditions in more than 500 cities, towns, and villages; the natural and structural conditions which increase the general hazard of cities, and the lack of laws or of their enforcement for the control of unsatisfactory conditions, are graded in the same way. The sum of the maximum points of deficiency totals 5 000 and is divided in accordance with the relative values of the features considered as given below.

Relative Values:

		Points.	
Water supply	Engine stream basis		1 700
	Hose stream basis	2 000	
Fire department	Engine stream basis		1 450
	Hose stream basis	1 150	
Fire alarm		550	
Police		50	
Building laws		200	
Explosives and inflammables		200	
Electricity		150	
Structural conditions		700	
		5 000	

A good water supply in connection with a poor fire department, or *vice versa*, is of less value than if both are good. In recognition of this, a modification of the better one of the two features is made, provided the divergence exceeds the equivalent of three classes.

In determining the points of deficiency to be applied to many of

the items, it appears reasonable to use a graduated scale of points depending upon the per cent. of deficiency, with a lesser increment for the first 30 per cent. than for the remainder; that is, a deficiency of 10 per cent. in good or moderately good conditions has less actual effect than where conditions are poor. Such a scale has been prepared and is given below; either the full scale, a multiple or a fractional part thereof is used, depending upon the relative weight or importance of the item under consideration.

DEFICIENCY SCALE.

(Points of deficiency corresponding to per cent. deficient.)

		10%.	20%.	30%.	40%.	50%.	60%.	70%.	80%.	90%.	100%.
		10	25	45	67	90	112	134	156	178	200
1%	1	12	27	47	70	92	114	136	158	180	
2%	2	13	29	50	72	94	116	138	160	182	
3%	3	15	31	52	74	97	119	141	163	185	
4%	4	16	33	54	76	99	121	143	165	187	
5%	5	18	35	57	79	101	123	145	167	189	
6%	6	19	37	59	81	103	125	147	169	191	
7%	7	21	39	61	83	105	127	149	171	194	
8%	8	22	41	63	85	108	130	152	174	196	
9%	9	24	43	65	88	110	132	154	176	198	

POINTS

To save space, this scale is printed in full above, and reference is made to it under each item to which it applies.

In all items, the total required quantity or the total required number must be used as the basis in figuring the percentage of deficiency, except that under Water Supply, if there is a deficiency under Item 6 *a*, the quantity available on which this deficiency was obtained shall be used as a basis in figuring the percentage of deficiency of Items 7 to 16, inclusive, except for the item on which the inadequacy occurs, in which case the total required quantity

will be used. Where quantity or numbers cannot be used as the basis, as in Items 2, 7, 10, 11, and 17 of Water Supply, the degree of deficiency shall be graded approximately as follows: Slight, 10 per cent.; moderate, 25 per cent.; considerable, 50 per cent.; serious, 75 per cent., and total, 100 per cent.

Subjects Considered in the Schedule.

Water Supply.

Item.

1. Appointment of Employees.
2. Efficiency of Executive.
3. Records and Plans.
4. Emergency Repair Provisions.
5. Receipt of Alarms by Department.
6. Normal Adequacy of Entire System.
7. Reliability of Source of Supply.
8. Sufficiency of Reserve Pump Capacity.
9. Sufficiency of Reserve Boiler Capacity.
10. Condition of Equipment.
11. Fuel Supply or Electric Power.
12. Construction of Pumping Station.
13. Fire Protection of Pumping Station.
14. Hazards of Pumping Station.
15. Exposures to Pumping Station.
16. Reliability of Supply Mains as Affecting Adequacy.
17. Reliability of Installation of Supply Mains.
18. Completeness of Arterial System.
19. Reliability of Installation of Mains.
20. Effect of Small Mains in the High Value District Considered.
21. 4-in. Mains in System.
22. Dead Ends — 4- and 6-in. Mains.
23. Completeness of Gridiron of 6-in. Mains.
24. Quality and Condition of Pipe.
25. Electrolysis.
26. Spacing of Gate Valves.
27. Condition of Gate Valves.
28. Distribution of Hydrants in the High Value District Considered.
29. Ditto in Residential Districts.

30. Condition of Hydrants.
31. Small Hydrants.
32. Valves on Hydrant Branch.

NOTE. — The items covered under Fire Department, etc., are omitted in this report.

CLASSIFICATION OF CITIES AND TOWNS BASED ON THE RELATIVE NUMBER OF POINTS OF DEFICIENCY IN FIRE DEFENSES AND PHYSICAL CONDITIONS.

A First Class City or Town is one receiving	0 to 500 points of deficiency
A Second Class City or Town is one receiving	501 to 1 000 points of deficiency
A Third Class City or Town is one receiving	1 001 to 1 500 points of deficiency
A Fourth Class City or Town is one receiving	1 501 to 2 000 points of deficiency
A Fifth Class City or Town is one receiving	2 001 to 2 500 points of deficiency
A Sixth Class City or Town is one receiving	2 501 to 3 000 points of deficiency
A Seventh Class City or Town is one receiving	3 001 to 3 500 points of deficiency
An Eighth Class City or Town is one receiving	3 501 to 4 000 points of deficiency
A Ninth Class City or Town is one receiving	4 001 to 4 500 points of deficiency

A Tenth Class City or Town is one receiving more than 4 500 points; or without a water supply and having a fire department grading tenth class; or with no fire protection.

STANDARD GRADING SCHEDULE.

Water Supply.

It is recognized that a so-called gravity system, i.e., one delivering supply directly to the city from the source without the use of pumps, is preferable from a fire protection standpoint, but a well-designed and properly-safeguarded direct pressure system, such as the high-pressure fire systems of some of our large cities,

so nearly approaches the gravity system in adequacy and reliability that no distinction is made between the two types.

The introduction of storage, either elevated and supplying the distribution system or for suction supply, offsets to a greater or less degree the need of duplication in various parts of a system, the value of the storage depending upon its amount and location; as affecting reliability of supply, it appears to be a reasonable assumption that a storage sufficient to meet maximum consumption demands for five days and leave a ten-hour fire flow available is sufficient to permit the making of most of the repairs, alterations, or additions incident to the operation of a water-supply system, and this assumption will be used as a basis in determining the extent of deficiency under Items 8, 9, and 16. The amount of storage and the probable time required to make repairs shall be taken into consideration in deciding on the degree of unreliability of Items 7, 10 to 15, and 17. In general, all storage lessens the requirements of those parts of the system through which supply has already passed. In no case can a rate in excess of the actual capacity of the mains from the storage be considered. Owing to the decrease in pressure when water is drawn down in standpipes, only the capacity of the top twenty-five feet can be considered as storage, unless situated on elevated ground and supply is to fire engines. Where storage fluctuates as much as 10 per cent. during the twenty-four hours, the minimum storage maintained must be used in the calculations. Capacity of pumps shall be considered on basis of present capacity, with proper allowance for loss due to condition.

The ability to utilize emergency supplies through connections to another system, or from a separate source or storage not normally used, must be considered in charging for deficiencies in the system under consideration, and credit given for the supply thus available at such pressures as may be required for adequate protection. These supplies are divided into two groups:

First, those owned or controlled by the same management as the system. Full credit may be given under items of reliability (Items 7 to 17, inclusive), where the supply comes in automatically or where definite arrangements are made for quickly drawing from the emergency supplies, with detail plans on file, showing

locations of gates and pipe lines. If no such arrangements and plans, or the emergency supplies, because of pollution, would be used only after conflagration conditions existed, credit shall be given for only one half the points which these supplies decrease the deficiency of the system. Under adequacy (Item 6) the above credits will be made only where the emergency supply can be turned in within thirty minutes, unless sufficient storage is available to maintain adequate supply for a period of two hours.

Second, those under outside control, where no contract agreement provides for their utilization by the employees of the system. These shall be applied only for Items 7 to 17, inclusive, under which credit shall be given for one third the points by which the quantity available from these supplies decreases the deficiency of the system.

Where a system is supplied from two or more sources of supply works, or where there are two or more systems serving the same area, the source or system furnishing the maximum protection shall be considered as the primary one; if one system is available at direct hydrant stream pressure, the low-pressure system may be considered only up to $\frac{3}{2}$ the engine capacity available. Application shall be made to the primary source or system, the deficiency of which is to be offset in whole or in part in any individual item by the additional protection afforded by the secondary source or system. Where the system graded covers only the district considered, Items 21 to 32, inclusive, must be based in whole or in part on conditions in the other system. In grading cities where high-pressure fire systems furnish protection to only a part of the district considered, separate gradings shall be made for the part thus protected and the part distant 300 ft. from the boundary hydrants of the area protected.

Where a water system exists, and canals, streams, ponds, wells, and cisterns make suction supply for engines also available, the suction supply may be considered in its ability to offset the deficiency in the various items where it would apply, but not in excess of the engine capacity available; in general, the only items affected will be Nos. 20, 28, and 29. Where no water system exists, such suction supply shall not be graded under Water Supply, a full deficiency of 1 700 points being allowed; the availability

of such supplies shall be considered in estimating the value of engine capacity and hose, as outlined in the Short Method of Grading Fire Departments.

The requirements given hereinafter are based in part upon the assumption that the maximum daily consumption is 50 per cent. in excess of the average, but in all cases of application the actual average consumption for the year previous shall be taken as the average consumption, and the maximum consumption for any twenty-four hours in the past three years taken as the maximum consumption, unless conditions have so changed that this maximum will not occur again.

In estimating required fire flow, an allowance is made for probable loss from broken service connections incidental to a large fire. Including this allowance, the total fire flow which should be available is approximately as given in the table below (based on formula $G = 1\,020\sqrt{P}\,(1 - .01\sqrt{P})$, where G = gallons per minute and P = population in thousands); but in all cases consideration must be given to the structural conditions as found in the city and also to the number of companies in the fire department and the amount of outside aid that would be called upon in case of a serious fire. The ratio of the total engine capacity to the fire flow required will be approximately as 2 to 3.

Population.	Required Fire Flow, Gallons per Minute, for the Principal High-Value District for an Average City.	Population.	Required Fire Flow, Gallons per Minute, for the Principal High-Value District for an Average City.
1 000	1 000	28 000	5 000
2 000	1 500	40 000	6 000
4 000	2 000	60 000	7 000
6 000	2 500	80 000	8 000
10 000	3 000	100 000	9 000
13 000	3 500	125 000	10 000
17 000	4 000	150 000	11 000
22 000	4 500	200 000	12 000

Over 200 000 population, 12 000 gal. a minute, with 2 000 to 8 000 gal. additional for a second fire.

In residential districts: For villages or towns under 10 000 population, 500 to 1 000 gal. a minute, where the district is not congested; for cities over this population, or where the district is congested, 1 000 to 3 000 gal. a minute, with up to 6 000 gal. a minute in densely built sections of three-story buildings.

In considering the adequacy of the domestic water supply under Item 6, *a* and *b*, the fire flow is assumed in all cases as being

delivered to the district considered at a pressure requiring the use of fire engines; that is, the pressure under full flow must not drop below 20 lb., except that a minimum of 10 lb. is permissible in districts having no deficiency in Items 28 and 31 and having all hydrants provided with at least one steamer outlet. If pressures are sufficient to permit direct hydrant streams, the need of fire engines is considered as offset, except for high buildings as required in Item 13 *b*, Fire Department. Where a deficiency exists in both engine capacity and direct hydrant streams, and the deficiency is greater in the former, consideration may be given under Item 6 *c* to the deficiency in fire flow at direct hydrant stream pressure. When application is not made under 6 *c*, all items figured to 20 lb., except as noted where no engines are available. For direct hydrant streams, a residual pressure of at least 75 lb. is required in high-value districts, except that where not more than ten buildings exceed three stories, a residual of 60 lb. is permissible. In closely built residential districts, a residual of 60 lb. is considered sufficient for direct hydrant streams; in thinly built residential sections, or in villages where buildings do not exceed two stories in height, a residual pressure of 50 lb. is considered sufficient.

When pressures permit direct streams and $\frac{3}{2}$ the engine capacity is not in excess of the quantity thus available, Items 8, 16, 18, 20, 21, 22, 23, and 28, Water Supply, shall be considered in respect to the ability to deliver water at direct hydrant stream pressure, except that where a deficiency exists in Items 8 and 16 at hydrant stream pressures, an allowance for fire flow at less pressure may be made, not to exceed $\frac{3}{2}$ the total actual engine capacity in service in the Fire Department.

1. Appointment. Employees on municipal systems to be under adequate civil service rules, properly administered, with tenure of office secure. Long tenure of office and an efficient organization considered the equivalent.

Appointments not under civil service for indefinite terms. Use $\frac{1}{10}$ Deficiency Scale.

2. Chief Executive (superintendent or chief engineer) to be

competent and qualified by experience, preferably supplemented by education, to efficiently fill the office.

Inexperienced or incompetent: Use $\frac{1}{10}$ Deficiency Scale.

3. RECORDS AND PLANS of the physical structures and operation of the system to be complete, in convenient form, safely filed, in duplicate, indexed, and up to date.

	Points.
Records or plans:	
a. Slightly incomplete.	**5**
b. Moderately incomplete.	**10**
c. Very incomplete.	**25**

4. EMERGENCY CREWS shall either be on duty at all times or quickly available; an emergency wagon, preferably motor-driven, loaded with necessary tools, shall be provided. At least one responsible employee familiar with the system shall respond to fire alarms in mercantile districts, and to second alarms elsewhere.

	Points.
Emergency provisions:	
a. Fair.	**5**
b. Poor.	**15**

5. ALARMS OF FIRE shall sound in some quarters of the department. Alarms shall sound in pumping stations of direct pumping systems; where pressures are raised to furnish direct hydrant streams, or pumps are started to furnish fire service, duplicate alarm circuits shall be provided as to fire stations; telephone service to pumping station shall be considered as 25 per cent. of total requirements. Lack of operating force on duty equivalent to deficient alarm service.

	Points.
Means of receiving fire alarms: Alarms not received by the department.	**10**
In direct pumping system use $\frac{1}{10}$ Deficiency Scale for deficiency at pumping station, or $\frac{1}{5}$ Deficiency Scale if pressures are raised for direct hose streams.	

6. ADEQUACY, AS REGARDS CAPACITY, OF SOURCE OF SUPPLY AND SUPPLY WORKS, TO DELIVER REQUIRED SUPPLY TO THE DISTRICT CONSIDERED. In this item there must be considered the normal ability of the source of supply, including impounding reservoirs, and of each part of the supply works to maintain maximum consumption demands and fire flow corresponding to the population as specified in the table hereinbefore given. Because of local conditions, a lesser or greater fire flow than called for by the population figures is sometimes deemed sufficient or necessary; in such cases the same fire flow shall be used in Items 8, 11, 16, and 21. In considering the source of supply, if shortage of supply is intermittent, apply deficiency under Item 7; if practically constant, as from wells, apply under Item 6. Under Supply Works, which includes intakes, suction lines, pumps, boilers, stacks, air compressors, filters (if not by-passed), and force or supply mains, storage shall be assumed as offsetting only deficiency in ability to deliver fire flow, and not deficiency in ability to meet consumption demands, except that where storage is large and records indicate no shortage in domestic consumption, it shall be assumed that no deficiency exists, if ten hours' fire flow could be obtained throughout this period for cities over 2 500 population, and five hours' fire flow for cities under this population. Filters may be assumed as capable of 25 per cent. overload capacity.

In considering the deficiency under this item, results obtained at fire flow tests in the most favorable location in the district shall be used as a basis in making calculations as to the probable deficiency under maximum consumption conditions, due allowance being made for any emergency supply. The extent of deficiency of each part of the supply works must be considered and the percentage of deficiency of the most serious used.

a. For average domestic consumption and fire flow: Use 2 times Deficiency Scale.

b. And add for maximum domestic consumption and fire flow: $\frac{1}{2}$ Deficiency Scale.

When direct hydrant streams are used by the fire department, and the engine capacity available (including the quantity from

high-pressure fire systems) is less than $\frac{2}{3}$ the fire flow obtainable at time of maximum consumption from the domestic system in the weakest part of the district at pressures permitting direct hydrant streams, apply a deficiency under sub-item *c.*; this deficiency to be based on the proportion of the total fire flow required available at the strongest point in the district.

c. For fire flow available at the strongest point in the district at pressures permitting direct hydrant streams:
Use $1\frac{1}{2}$ times Deficiency Scale.
Deduct 10 per cent. of points of deficiency for each 10 per cent. of engine capacity available, this per cent. to be based on $\frac{2}{3}$ fire flow required.

7. Reliability of Source of Supply. The effect on adequacy must be considered for such items as frequency and duration of droughts, physical condition of intakes, danger from earthquakes, floods, forest fires, ice dams and other ice formations, silting-up or shifting of channels, absence of watchmen where needed, or injury by physical means. No item is to be considered which is covered by requirements hereinafter given.

Use 2 times Deficiency Scale in proportion to degree of unreliability, as given on page 13.

8. Reliability of Pumping Capacity on which supply is dependent, shall be on the following basis:

Pumping capacity must be such, with the two largest pumps out of service, as to maintain maximum consumption and fire flow at required pressure; for cities under 25 000 population, maximum consumption and $\frac{1}{2}$ fire flow, and for cities under 2 500 population, maximum consumption and $\frac{1}{4}$ fire flow.

Deficiency, when pumping capacity under conditions given below in *a* and *b* is less than maximum consumption, shall be considered as offset by storage when the difference between maximum consumption and the output of the pumps is equaled by $\frac{1}{5}$ the storage after deducting fire flow for ten hours; when pumping capacity is greater than maximum consumption, the excess capacity plus 2.4 times the storage shall be considered as offsetting deficiency if equal to the fire flow in million gallons a day.

In cases where both low-lift and high-lift pumps are provided and reliability of supply is dependent on each, they must be considered separately and the point of deficiency added. If, as in a system supplied by deep well pumps, the deficiency in adequacy of supply and pumps is equal, assume it as due to supply, and do not use required quantity as basis in this item.

Where capacity remaining, alone or in connection with storage, does not equal domestic consumption, the proportion available at desired pressure may be allowed; full credit will be given for all pumps capable of delivering against fire pressure.

a. Use Full Deficiency Scale for deficiency on basis of one pump out of service.

b. Add ¼ Deficiency Scale for deficiency on basis of two pumps out of service.

9. Boiler Capacity, with a reserve of one fourth the entire capacity, and in any case at least one boiler, must be sufficient to operate all machinery and the pumps required, as determined under Item 8, to maintain maximum consumption and fire flow, with allowance made for storage. In cases where both high- and low-lift pumping is used, the points of deficiency found under each condition must be added.

Normally, there must be sufficient boiler capacity, under at least ½ required steam pressure, to deliver full requirements, in connection with storage, for a period of two hours.

With sufficient stack or forced draft capacity, an overload of 50 per cent. over the maker's rating may be used for fire tube boilers, and 100 per cent. for water tube.

a. Use ½ Deficiency Scale for deficiency in boiler capacity.

b. Add ¼ Deficiency Scale for deficiency in boilers under steam.

10. Condition, Arrangement, and Reliability of Plant Equipment. The following forms and combinations of plant equipment, if of modern design and well constructed and installed, are assumed as approximately equal, advantages of each, if any, being in the order of their naming:

a. Centrifugal or reciprocating pumps driven by steam engines.

b. Centrifugal or reciprocating pumps driven by electric motor. Generating station must meet conditions of Items 7 to 15, inclusive, Item 8 to be generators instead of pumps, and deficiency applied.

c. Pumps operated by water power; must meet conditions of Item 7 and deficiency applied.

d. Centrifugal or reciprocating pumps operated by internal combustion engines approved for this service. Duplicate ignition parts must be on hand for each engine. Adequate provision must be made for starting engines cold at least six times in rapid succession.

All equipment must be of a design applicable to the service; service record in the plant under consideration and in similar plants shall be considered, and actual operating conditions observed. Pumps are to be free from knock, with low slip, and capable of operating at full speed. Boilers shall be well set, in good condition and with proper semi-annual inspection service; stacks shall be substantially installed. Electrical equipment for power shall be in accordance with National Electrical Code and not liable to injury by water spray. Water-power equipment must be accessible and properly safeguarded. Operating force shall be competent. Consider also arrangement of apparatus as to ease of repairs, etc.

On basis of capacity affected and degree of unreliability: Use Full Deficiency Scale.

Note. — A deficiency may apply under this item though there is no deficiency under Items 8, 9, and 11.

11. Fuel, and Accessories for the Transmission of Power. A minimum of five days' coal supply shall be provided; where long hauls, condition of roads, climatic conditions, or other causes, make a longer interruption of delivery possible, a greater storage shall be provided. Gas supply shall be from two independent sources, or from duplicate gas producer plant with a storage of at least twenty-four hours' gas supply. Oil supply shall be from underground storage of at least five days' capacity, with force feed to engine or boiler. Unreliability of gas or oil supply to boilers may be lessened by proper provisions for the use of coal.

Water for power shall equal at all times that necessary to meet maximum requirements (or other power provided to equalize deficiency) and shall have proper flood and ice control.

Steam piping (or gas or oil piping with internal combustion engines or to boilers) or electric transmission lines shall be so arranged that a failure in any line, or the renewal of a transformer or oil pump would not prevent maintaining, in connection with storage, maximum domestic consumption for two days and fire flow for ten hours; for cities under 25 000 population, maximum consumption for two days and ½ fire flow for ten hours, and for cities under 2 500 population, maximum consumption for two days and ¼ fire flow for ten hours. Overhead electric lines introduce a degree of unreliability which may be in part offset by storage; consideration in connection with such lines shall be given to number and duration of wind, sleet, and snow storms, character of poles and wires, character of country traversed, effect of forest fires, and ease of and facilities for repairs; the use of the same transmission line from the transformer or switchboard by other plants introduces a hazard of short circuit or prior use of power and may be considered as the equivalent to the use of overhead lines in applying the schedule.

a. Adequacy and reliability of fuel:
Use ¼ Deficiency Scale.

b. Electric lines, including transformers:
Use ¼ Deficiency Scale.
For overhead lines, add in proportion to unreliable service and installation, Full Deficiency Scale, and increase points of deficiency 1 per cent. for each mile length of overhead line on which normal service depends.

c. Steam, gas or oil piping:
Use ¼ Deficiency Scale.

Note. — Where stations are dependent upon each other for operation, a cumulative charge shall be made for the condition at each. Item a may apply in addition to b and c. When deficiencies in both items b and c occur in or to the same station, or stations performing the same service, apply only for the greatest deficiency.

PUMPING STATION:

12, 13, 14, and 15. Pumping stations and other portions of the plant shall contain no combustible material in their construction; otherwise an automatic sprinkler equipment shall be provided; outside hydrants and hose, inside standpipes and small hose, and chemical extinguishers shall be provided. Public fire station, if within $\frac{3}{4}$ mile, shall be considered as giving about $\frac{1}{2}$ protection. If pumping station is not fireproof, the several sections, particularly any with high potential generating equipment, shall be separated by parapeted fire walls, and openings protected by standard fire doors or wire glass in metal frames. Station shall be protected against exposures. Electric wiring shall be in accordance with the National Electrical Code and all internal hazards safeguarded.

Note. — Under Items 12 to 15, inclusive: Where two or more stations are not dependent upon each other for operation, apply deficiency to the best station in the proportion of its capacity to the total required, and to the other stations in the proportion of capacity necessary to obtain remaining required supply. Where stations are dependent on each other for operation, apply deficiency to each. Deduct one tenth the points for each day's storage in reservoir in excess of ten hours' fire flow.

	Points.
12. Construction:	
a. Small amount of combustible material in roof structure.	**10**
Or,	
b. Small amount of combustible material in roof and floors.	**15**
Or,	
c. Considerable amount of combustible material in roof structure, floors and wainscoting and / or partitions.	**25**
Or,	
d. Largely or wholly frame: for each 25 per cent.	**10**

Note. — If sprinklered throughout, do not consider a, b, or c, and charge only $\frac{1}{2}$ of d.

	Points.
e. Combustible roof covering.	**30**
f. Sections not properly cut off.	**10**

Note.— The deficiency may include e and f in addition to any other one item.

13. Insufficient fire protection, other than sprinklers.	
a. If 12 a or b applies.	**5**
b. If 12 c, d or e applies.	**10**
14. Hazards:	
a. Low potential wiring defective.	**5**
Or,	
b. Low potential wiring hazardous.	**10**
c. High potential wiring defective.	**10**
Or,	
d. High potential wiring hazardous.	**25**
e. Heating by stove or gas.	**5**
f. General care, including storage of oils, poor.	**5**
Or,	
g. General care, including storage of oils, very poor.	**10**
h. High potential generating or transforming apparatus; if in non-fireproof building and not cut off by blank parapeted wall.	**20**
15. No protection:	
a. To moderate exposures.	**10**
b. To serious exposures.	**25**

Note. — If 12 d or e apply, use double the points for 15 a and b.

16. Reliability of Supply Mains as Affecting Adequacy. Under this heading will be included any and all pipe lines or conduits on which supply to the distribution system is dependent; suction or gravity lines to pumping station, flow lines from reservoirs, force mains, etc., are included, and a system may have one or all of these as part of it. Under 6, the adequacy of these lines under normal conditions has been considered. Consideration must be as to greatest effect on maximum consumption and fire

flow at required pressure that a break could have; for cities under 25 000 population, maximum consumption and $\frac{1}{2}$ fire flow, and for cities under 2 500 population, maximum consumption and $\frac{1}{4}$ fire flow. In applying, all mains which deliver from a source of supply or of storage to the principal mercantile district must be considered. Aqueducts, of good design and of substantial construction, such as masonry or concreted steel, if so installed as not to be deficient under Item 17 following, shall be considered sufficiently dependable as not to require duplication, and no application will be made as to the effect of a possible break.

Under the assumption of the most serious single break, when capacity of mains from the source of supply is less than maximum consumption, deficiency shall be considered as offset by storage when the difference between maximum consumption and the capacity of the mains is equaled by $\frac{1}{5}$ the storage after deducting fire flow for ten hours, except as restricted by the capacity of the mains from the storage. If remaining mains and storage cannot deliver even maximum consumption, allow for only that amount available at required pressure.

When capacity of the mains from the source of supply is more than maximum consumption, the excess capacity plus 2.4 times the storage shall be considered as offsetting deficiency if equal to the fire flow in million gallons a day. The effect of a break in suction or discharge headers, lack of by-passing or poorly gated by-pass or arrangements at any reservoir, filter, etc., poorly arranged cross-connections, etc., must be considered; also features which would tend to cause or prevent an interruption of service, such as length of line, and two or more lines from the same or different sources or from storage.

Deficiency for each individual possible break must be considered, and charge made for the case giving the maximum total number of points, including the increase due to distance.

For maximum effect on domestic consumption and fire flow of any single break in any main, apply $\frac{1}{2}$ Deficiency Scale, and increase the points of deficiency by 1 per cent. for each 1 000 ft. of main in which a single break would produce this maximum effect.

For supply lines not under vacuum and entirely on private right of way, decrease the above total by 10 per cent. for each 10 lb. pressure less than 50 lb., for the maximum pressure carried on the lines.

17. Reliability of Installation of Supply Mains. Must be in good condition and reliable; cast-iron, wrought-iron, wood-stave, and masonry conduit have been found satisfactory in various places and under certain conditions; service records and general conditions must be considered. Mains shall be so laid as not to endanger each other, and their failure at stream crossings, railroad crossings, and other points where physical conditions are unsatisfactory shall be guarded against; they shall be cross-connected and gated about once a mile and be equipped with air-valves at the high points and blow-offs at the low points. The general arrangement of valves, specials, and connections at cross-overs, intersections, reservoirs, and discharge and suction headers must be considered, with the view to quickness in shutting down breaks and repairing valves.

Use ½ Deficiency Scale in proportion to degree of unreliability.
Note. — If more than one main and conditions do not affect all, apply in proportion to the carrying capacity affected, and the degree of unreliability. A deficiency may apply under this item even though there is no deficiency under Item 16.

18. Arterial System. In connection with the supply mains, arteries and secondary feeders shall extend throughout the system. These feeders shall be of sufficient size, considering their length and the character of the sections served, to deliver fire flow necessary for the district, shall be frequently spaced (about every 3 000 ft.) and looped. Basis of deficiency applied to be the results of fire flow tests and general consideration of the arrangement.

	Points.
a. Fair.	**10**
b. Poor.	**20**
c. Very poor.	**50**

19. Installation. Mains of the arterial system shall not be laid across filled ground, and shall have special construction at railroad crossings and near bridge abutments, and shall be so gated that not more than $\frac{1}{4}$ mile within the distribution system will be affected by a break. All mains shall have sufficient cover to prevent freezing, with a minimum cover of 2 ft. to prevent injury from traffic.

	Points.
a. Slightly unreliable.	**5**
b. Moderately unreliable.	**10**
c. Seriously unreliable.	**25**

Note. — Consideration not to be given to conditions already covered by 17 above.

20, 21, 22, and 23. Minor Distributors and Gridiron System. Six-inch is to be considered the minimum size satisfactory for hydrant supply in residential districts; to be closely gridironed with 6-in. cross-connecting mains at intervals not exceeding 600 ft.; or where initial pressures are high, a satisfactory gridiron may be obtained by a liberal per cent. of larger mains cross-connecting the 6-in. at greater intervals; in new construction, 8-in. should be used where dead ends and poor gridironing are likely to exist for some time, and 6-in. only where blocks are 600 ft. or less in length. In high-value districts, the minimum size is to be 8-in., with cross-connecting mains at distances as given above; 12-in. and larger mains to be on the principal streets and for all long lines not cross-connected at frequent intervals.

20. Effect of Small Mains in High-Value District Considered:

For deficiency in fire flow in the part of the district where the least supply is available, whether due to weakness in the system or low pressures: Use Full Deficiency Scale.

Per cent. of deficiency to be based on fire flow obtained at strongest point in district, except where this exceeds required fire flow, in which case the latter should be used as basis.

21. Small Mains in Distribution System:

For per cent. of 4-in. or smaller mains supplying hydrants: Use Full Deficiency Scale for cities over 10 000 population, and ½ Deficiency Scale for cities under 10 000 population.

Note.—Not to be considered where laid only to supply domestic consumption and hydrants are not directly supplied by them.

Reduce the points of deficiency 5 per cent. for each 10 lb. average normal static pressure above 20 lb. in cities depending on engine streams and 60 lb. in cities without engines or depending on hydrant streams.

Use as normal static pressures the fire pressures regularly carried on second alarms.

22. Dead Ends. — For per cent. of 6-in. and 4-in. pipe, dead-ended, on basis of total length of pipe in the distribution system, to include dead ends at service limits: Use Full Deficiency Scale.

Reduce the points of deficiency 5 per cent. for each 10 lb. average normal static pressure above 20 lb. in cities depending on engine streams and 60 lb. in cities without engines or depending on hydrant streams. Use as normal static pressures the fire pressures regularly carried on second alarms.

23. Gridiron (average condition in closely built residential sections): 6-in. or smaller mains on long side of block, with 8-in. or larger cross-connections:

	Points.
a. At intervals of 600 to 900 ft.	15
b. „ „ „ 901 „ 1 200 „	30
c. „ „ „ 1 201 „ 1 500 „	45
d. „ „ „ 1 501 „ 1 800 „	65
e. „ „ „ 1 801 „ 2 100 „	85
f. „ „ „ 2 101 „ 2 400 „	100
g. „ „ „ 2 401 „ 3 000 „	115

If cross-connections are 6-in. or smaller, increase points of deficiency by 50 per cent.

Reduce points of deficiency 10 points for each 10 lb. average normal static pressure above 20 lb. in cities depending on engine streams and 60 lb. in cities without engines or depending on hydrant streams. Use as normal static pressures the fire pressures regularly carried on second alarms.

Do not apply Item 23 where deficiency under Item 22 exceeds 75 per cent.

24. PIPE. In distribution system, pipe must be of satisfactory quality and properly tested for soundness and tightness of joints. The use of cast-iron pipe under pressures more than double that specified for the class is considered as introducing an unreliable feature, particularly where pressures are raised for fires; tests before backfilling and service records of several years' duration may be assumed as offsetting in part this defect.

Use ½ Deficiency Scale for cement-lined pipe, and ½ Deficiency Scale for wooden or metal pipe in unreliable condition.

25. ELECTROLYSIS conditions are to be studied and methods of prevention applied.

	Points.
For conditions favorable to electrolytic action.	**10**

Note.—If there is evidence of recent serious electrolytic action, double the above points.

26. GATE VALVES. The distribution system shall be equipped with a sufficient number, so located that no single case of accident, breakage or repair to the pipe system, exclusive of arteries, will necessitate the shutting from service a length of pipe greater than 500 ft. in high-value districts, or greater than 800 ft. in other sections, and will not result in shutting down an artery.

	Points.
Spacing in high-value districts:	
a. Average 600 to 900 ft.	**10**
b. Average over 900 ft.	**25**
Spacing in residential districts:	
c. Average 900 to 1 500 ft.	**5**
d. Average over 1 500 ft.	**15**

27. INSPECTION AND CONDITION OF VALVES. All valves shall be inspected yearly and large valves more frequently, and be kept in good condition; the presence of some valves operating in opposite direction is to be considered the equivalent of unsatisfactory condition, ranging from fair to poor, depending on the number and importance.

Points.

Gate valves not inspected regularly or in poor condition. 20

28 and 29. HYDRANT DISTRIBUTION. Shall be sufficient to give an average area served, in proportion to the fire flow, as given below; where no engines are in service, direct hydrant stream spacing to be required. Four- or 6-way hydrants with independent gates on outlets may be assumed as two hydrants in figuring area served.

Fire Flow Required, Gal. per Minute.	Average Area per Hydrant, Sq. Ft.
ENGINE STREAMS (150 lb.).	
1 000	120 000
2 000	110 000
3 000	100 000
4 000	90 000
5 000	85 000
6 000	80 000
7 000	70 000
8 000	60 000
9 000	55 000
10 000	48 000
11 000	43 000
12 000	40 000
DIRECT HYDRANT STREAMS (75 lb.).	
1 000	100 000
1 500	90 000
2 000	85 000
2 500	78 000
3 000	70 000
4 000	55 000
5 000 and over	40 000

Points.

28. **Area served in high-value districts in excess of requirements.**

For each 10 000 sq. ft. 10

The area of a high-value district is to be bounded by a line midway between the nearest inside and nearest outside hydrant, but not exceeding 300 ft. from the inside hydrant. If at direct hydrant streams, fire flow in weakest part of the district exceeds the engine capacity available, apply on direct hydrant stream basis.

29. **Area served in the residential district in excess of requirements.**

	Points.
For each 10 000 sq. ft. that area in which block fronts have $\frac{1}{3}$ the lots built upon, but to exclude the high-value district.	**3**

The maximum charge for no hydrants in the residential district is to be 400 points. If on first alarm in residential district, an average of one half the companies are engines, use engine basis.

30. CONDITION OF HYDRANTS. Hydrants shall be inspected in the spring and fall of each year, after use at fires during freezing weather and daily in high-value districts during protracted periods of severe cold.

	Points.
a. Not inspected, or in only fair condition.	**10**
b. In poor condition.	**20**

31 and 32. SIZE AND INSTALLATION OF HYDRANTS. Hydrants shall be able to deliver 600 gal. per minute, with a loss of not more than $2\frac{1}{2}$ lb. in the hydrant and a total loss of not more than 5 lb. between the street main and outlet; they shall not have less than two $2\frac{1}{2}$-in. outlets and also a steamer connection where steamer service is necessary. Street connection should be not less than 6 in. in diameter; connections to street main shall be gated. Hose threads on outlets should conform to the National Standard. Flush hydrants, requiring chucks to be screwed on, are considered undesirable, especially in sections of the country subject to heavy snowstorms, because of delay in getting in operation.

31. **Hydrants too small; to include all with 4-in. connection to main, or those having a friction loss greater than noted above, except those hydrants with steamer outlet in cities using engines and with static pressure of at least 60 lb.; also to include all with single 2½-in. outlet, and all flush hydrants requiring chuck to be screwed on or where covers are liable to be covered by heavy snow fall, except that flush hydrants, with an adequate number of chucks provided having more than one 2½-in. outlet, are to be considered on basis of ½ deficient. If in high-value district considered there are more hydrants than are required for proper spacing, and the small hydrants are not generally used by the fire department, use in determining the deficiency only the number of small hydrants required to make up the total number necessary for proper distribution; i. e., do not charge for the surplus small hydrants.**

a. **Use ⅓ Deficiency Scale for those in high-value districts.**

b. **And add 1/10 Deficiency Scale for those elsewhere.**

	Points.
32. **Hydrant connections to street main not gated: Each 10 per cent.**	1

If 26 b or d apply, use double the points.

If no deficiency under 26, do not apply 32, unless hydrants on main arteries are not gated, in which case use a total of 10 points.

DISCUSSION.

MR. C. W. SHERMAN. One thing already in our JOURNAL is so pertinent in this connection that I cannot refrain from quoting it. Mr. Frank A. Barbour, in his paper entitled, "Insurance Rates and the Water Service," * referred to three or four cities where he had recently, at that time, assisted in radically improving the water-works system. He put in this statement: "It is safe to say that in none of these cases was there any attempt

* JOURNAL N. E. W. W. A., xxii, 322.

to estimate the value of the improvements in reducing the fire hazard on any definite basis derived by experience and made applicable by records of fire losses in relation to the character of the water service. It would seem, however, that the time must soon arrive when such logical proportioning of rates to the factors comprising fire hazards will be possible."

It has been eight years since that was presented, so perhaps it has not come quite so soon as Mr. Barbour thought it might logically follow. Nevertheless, in those cases it was only by strenuous exertion, and usually after the improvements had been made, that any improvement in the insurance rate was obtained, but in the cases quoted by Mr. Barbour insurance deductions were finally obtained, which in large measure compensated for the cost of the improvements actually made.

MR. GEORGE W. BOOTH.* I want to express to you at the start our appreciation of your coöperation and to say that we shall be glad to have, from any member of the Association, his comments on any part of the schedule. We hope within the next month to present the schedule to the National Board Committee having the matter in charge, with the idea of issuing a revised edition which we can recommend for adoption by insurance organizations generally.

I would like to mention also the fact that the New England Insurance Exchange, which operates in this territory, has for the past year or so been applying a schedule which, although it goes into less detail than the National Board schedule and considers only a few of the principal fire protection features, does undoubtedly give very much more consistent results than were obtained previously. This schedule and classification have as yet been applied only to dwelling-house rates.

Concerning the questions raised by your committee: First, that of connections to distribution system, I feel that a sharp distinction should be drawn between connections to automatic sprinkler systems and those for manufacturing purposes, elevators, standpipes, etc. The automatic sprinkler system is one of the greatest of fire preventers, and to be effective, we are agreed that the connection should be of adequate size. What this size

* Chief Engineer National Board of Fire Underwriters, New York.

should be is a question that has been often debated in this Association, and I will not attempt to discuss it here. Personally, I believe that the proper way to attack the problem is to safeguard these connections in every possible way, so that flow from them may be controlled when necessary, rather than to insist on a limiting size which will be in some cases of doubtful adequacy; to install a size smaller seems to me only a partial and unsatisfactory solution of the problem. I am ready to admit that there is in some quarters a tendency to demand connections larger than there is any reason or necessity for, but I hope that it will be possible in the near future to secure recognition for reasonable standards. In this connection, I want to draw your attention to the likeness between the connection to an automatic sprinkler system and a fire hydrant; you will agree that it would be poor policy to provide too small a hydrant branch, with the idea of limiting waste when a hydrant, especially one opening with the pressure, may be broken off, as they not infrequently are; likewise, it very frequently happens during large fires or conflagrations that the rapid spread of fire compels the abandonment of a hydrant left open and wasting large quantities of water. On the other hand, there have been comparatively few cases where the breaking of connections to automatic sprinkler systems, as distinct from other large connections into buildings, has resulted in a serious waste of water.

As to the question of recognition of the 4-in. hydrant, it is not out of the question, nor even difficult to design a hydrant with 4-in. foot valve which will meet the capacity requirements of the schedule; Mr. McInnes's experience in the design of a hydrant for the Boston high pressure system shows that to be a fact. And, even though none of the commercial 4-in. hydrants meet these requirements, some of them come pretty near it. I think we can dispose of the problem as presented by means of a provision we contemplate making, to exclude from consideration in the schedule, outlying sections detached from the district which is being classified, or which are so remote from it as not to offer any exposure hazard.

The gravity cities, as a rule, will grade better than the direct-pumping cities, because there are fewer items to be considered,

fewer chances of interruption of service. As a rule, your New England cities, being largely of the gravity type, show up better than those in the Middle West, where it is necessary to depend on direct pumpage.

MR. R. J. THOMAS.* I should like to say a word in regard to the importance of this question in our city. Probably it is the case of most of the cities of Massachusetts. Considerable money has been spent in the last five or ten years in improving the water-works system, with a view of extinguishing fires. Larger mains have been laid, more hydrants have been installed, and considerable money expended in order to put the city in a position to protect itself from conflagration or large fires.

In the city of Lowell, within the last eight years, we have expended, on the recommendation of the National Board of Underwriters, about $300 000. I presume other cities have gone along in the same line, towards carrying out the recommendations of the Board; with the result that the insurance rates have not decreased, but have increased. I think in every city in Massachusetts the insurance rates have increased quite considerably — I understand about thirty-three per cent. on some classes of property.

Now, the trouble is not with the National Board of Underwriters, nor with the cities making the improvements, but it is with the insurance organizations, the men who have the control of fixing the rates; the men that are doing the financing; the men who look upon the insurance companies as a business.

We approach the different rating committees, who have meetings at Boston at the New England Exchange, and it is difficult to arrive at an understanding between the different cities and the insurance committees. They take the financial view of it, the insurance view, while the cities, of course, are also looking for a decrease in insurance rates, as they reasonably should expect to do, considering the expense that they have been to in making improvements.

The National Board of Underwriters, as I view it, is just the medium for the water-works people to look to for bringing about

* Superintendent of Water Works, Lowell, Mass.

a better understanding with the insurance organizations. The National Board of Underwriters, or their engineers, at least, are water-works men. They have water-works ideas, and look at the matter from our standpoint, and will be a great help to the water department, or the fire department, and the city interests in general who are making these improvements. The National Board will help us in getting a reduction commensurate with the improvements that we make. Therefore this new grading schedule ought to be something we should adopt; something we should favor, and something we should support in every way possible.

At the present time, as I understand it, they have a schedule that applies mostly to residential property, classified A, B, C, and so forth. There are very few cities in New England — and I believe but two or three in Massachusetts — that come under the classification of Class A. Most of them are in Class B. In our efforts in Lowell to be placed in the Class A rating, we found it was almost impossible for us to put the city in shape to come under that classification, under the present schedule, but we hope under this new schedule, under this new grading, to have a good deal better standing. We expect to be credited with the amount of money spent in making these improvements. Of course, we are in just the same position as every other city and every other water-works department in New England. They all undoubtedly want to get credit for the money expended; expended upon the recommendation of the Board of Underwriters, and by supporting the National Board is the only way I know of that we can reach the insurance interest and get it.

Undoubtedly, the insurance organizations will be guided by this schedule, and by their advisers, the National Board and their engineers, and I hope all the members will look into this subject, and give it considerable thought, because the insurance rates are a matter of great importance to every community. Of course, the higher the insurance rates, the more dissatisfaction you will have among your people over the money expended. Aside from any expectation of reduction of the insurance rates, every water department superintendent and every public official wants, in so far as the city is able, to protect the city against a conflagration such as occurred in Salem and in Chelsea. By working along

these lines, and under the advice of the National Board, we will be achieving that purpose.

It seems to me that the schedule as laid down by the National Board is substantially as good as can be devised by engineers, who have the knowledge of not only the water works but the fire department and the features that go to make up the grading basis.

I hope that some of the members who have different views may give expression to them this morning, so that we can have something to work on.

MR. FULLER. I should like to ask Mr. Booth if the matter of sprinkling schoolhouses is in any way compulsory, and if it is not, why it should not be.

MR. BOOTH. So far as this schedule is concerned, the compulsory sprinkling of any class of buildings has not been considered. That is to be taken care of by state law, or, as in the case of Boston and vicinity, the fire prevention commissioner. It is not possible by any insurance regulations to compel the sprinkling of anything. There are cities that do have ordinances regarding the sprinkling of basements, for instance. But I think there is no state law.

One thought that Mr. Thomas suggested, and that is the difficulty in arriving at an understanding in regard to reasonable rates of insurance. One reason why that has not been possible is because there have not been any classified records of fire losses, to enable either the fire insurance companies or anybody else to say what is a fair rate. About a year ago, the National Board established a new bureau, the Actuarial Bureau, which is intended to do just that, and beginning with the 1st of January, 1915, those records have been kept. For the first year it was experimental in a way, because it was a big job, and nobody knew just what they wanted or how to go about it, so the first year records will not be so valuable as they ought to be from now on.

Those records are classified by states; that is, the fire loss in each state, and for each of about two hundred classes of property and occupancy. When the records are completed, you will be able to tell, for the year 1916, what the fire loss in the state of Massachusetts was, in either one of two or three different kinds of construction, and many kinds of occupation. It is a big con-

tract, and had to be gone about very slowly. Whether that can be used in all its refinements as a basis for making rates, in my opinion it will certainly be a very large factor in determining what the proper rate is.

MR. W. C. HAWLEY.* This is an age of efficiency, and we must expect our plants to be efficient, and, in addition, furnish first-class fire protection.

As I look back to the discussions which we have had in this Association, years ago, and think of the wide divergence of views of the insurance men and the water-works men, I am glad to see that we have come so near together. That was brought out particularly at the June meeting of the American Water Works Association, — the matter of size of pipe and connections for fire protection. The insurance men have come practically to the views of the water-works men, whereas a few years ago they wanted service much larger than we were willing to grant.

I think this proposed plan is a most excellent one, and if it will only filter down from the heads of the insurance companies to the people that we come in contact with, out on the firing line, as it probably will in time, it certainly will be a fine thing.

In my own town, about two years ago, we found that the commercial risks were paying a penalty, I have forgotten how many cents, for lack of pressure, although in the business district and in a large part of the residential district of our town we had a pressure of from 125 to 175 lbs. per square inch. We were also paying a penalty for lack of required-sized mains, and when our board of trade took that matter up with the County Board of Underwriters we were informed that, because there were some 4-in. mains in our city, the penalty would stand. It made no difference, although I offered to demonstrate that we could throw more than twice the number of effective fire streams, nearly three times the number of effective fire streams, that the secretary of the board thought there should be available. That made no difference, that penalty still stands.

I hope that this work which is in progress now will ultimately reach our section of the country, and help us out in the proper adjustment of insurance rates.

* Chief Engineer, Pennsylvania Water Co., Wilkinsburg, Pa.

MR. R. C. P. COGGESHALL.* Our situation in New Bedford is different from most any other city. Every drop of water that is used by our industries has to be supplied by the water department. There is no secondary supply, such as there is at Lawrence, Fall River, Holyoke, and Manchester. It all has to come from the city of New Bedford. The consequence is, that at times — especially Monday morning, for instance — the draft upon our reserve is upwards of 20 000 000 gal., or at that rate. The result is that we have large mains, so as to equalize the pressure in all parts of the town, and that has been an incentive to getting a pretty reliable supply there. We have made it a point to remove all the small mains. The 4-in. are generally replaced with an 8-in. size. The result has been that we have pretty fair fire protection there now; but, while the water works and water department have done their duty in the city of New Bedford, the building laws are most terrifically lax, and it seems as if in the same proportion that we have made the water supply more reliable, the fire hazard has increased. You need none of you be surprised, some day, to have a huge conflagration, when the conditions come right; and, with the admirable supply, the mills are more exposed to a fire hazard from outside than they are from inside. Under a southwest wind, blowing over the city and going against those mills, there may be a terrible conflagration.

I think, sometimes, we may look to the building laws, and to stricter building laws, to better conditions. The erection of these three deckers in huge blocks, in the vicinity of the mills, is perhaps one reason why we have not reduced the insurance rates there.

Perhaps Mr. Booth can tell us something about that, whether or no the water departments have not done their duty, where the city has been very lax in administering the building laws.

MR. BOOTH. It is perfectly true, as Mr. Coggeshall intimated, that the worst feature, in almost all cities we know of, now is the building condition. You can provide, as he has in New Bedford, a perfectly good water supply, and the city can provide, as it has in New Bedford, a better than normal fire department, and you have still got the conflagration hazard there; and it is a peculiar

* Superintendent Water Works, New Bedford, Mass.

thing that it is a great deal more difficult to get a city to establish a good building code and enforce it than it is to get them to spend money, especially in the fire department, as it appears. Perhaps you can guess for yourselves why that may be, in your own individual city, but it is true. It is a good deal more difficult to get them to pass reasonably good laws on building construction and enforce them than to get them to spend money for something that looks pretty, and makes a good show.

The weight to be given, in the schedule, to building laws has been debated quite considerably. On one side, some men would say there should be no weight given to building laws at all; it should not be considered in the schedule, because it will be given weight in its results when they are attained; that is, when you improve your building construction, you naturally get the benefit both in the schedule rating and in your individual building rating, but that item was left to encourage the adoption of good building laws, even though they might not result immediately or for some time in any material betterment of actual conditions.

One reason why we could not give more weight in the schedule to actual building conditions, as covered by structural conditions, — the last part of the schedule which you have not had printed here, — was that they would overbalance the features of protection, and, besides that, and particularly, the poor features of the individual building are penalized in the building rate itself. But the weight that is given to building construction in this schedule refers only to what we call the general conflagration hazard; that is, the effect on conditions in the district as a whole of the poor construction of any individual building or block.

Mr. H. V. Macksey.* In considering the report of this committee, I hope the members will remember that it really is a progress report; that we are only making progress along the lines that we have started on, and the underwriters are merely making progress. They have not yet reached a point where they are prepared to say, "This is the thing that is going to last." They have not yet reached a point where all the underwriters in the various sections of the country will place the valuation on fire protection, building hazard, all that sort of thing, but they are

* Superintendent of Public Works, Woburn, Mass.

trying to reach something that will be reasonable and equitable, and that will finally guide those who make the rates for fire protection in various cities.

While a very short time ago, when the matter was first projected in this Association, I believed that it would be useless for us to confer with them or attempt to assist them, I have since changed my mind, because I find that the representatives of the National Board, not only in this particular case but in others, are working on the proper lines. They are reasonable men, and trying to get assistance from us, and not trying, as some of the little fellows in the underwriting business, to browbeat us, to get the particular things that please them, from time to time. So we have worked along with the representatives of the National Board, and have agreed with them on many things, disagreed with them on a few, and there are others that just now we don't know what we should properly say.

Take the matter of the building hazard, which has just been under discussion. It is very plain that the building laws should have greater value than they are given, provided you could change them to-day and enforce them to-day, and make them effective on buildings already erected. Any change which you make in the building law of to-day will not affect buildings now constructed; and the buildings now constructed, I suppose, will last on an average of forty to fifty years. So that any small difference in the penalty charged against the city on account of building laws would have very little immediate effect, and even a large one would not have great effect.

In talking on the various items in the water department, the committee did not agree with the underwriters on a few points, and I think the principal ones were the penalizing of a 4-in. valve hydrant. A majority of the committee is strongly convinced that that hydrant should not be penalized, and that the matter of a slight reduction in pressure of the hydrant is of very little importance in a very great part of the field in which the hydrants are used; that while it may be valuable in crowded portions of large cities, in the suburban and country districts throughout the country it is of very little importance whether you have a 4-in. or a 5-in. valve hydrant. So many hydrants are taken off long

lines of 6-in. pipe, and so many fires are small affairs, attended by only one piece of apparatus, that, to our minds, it is fair to say that the 4-in. valve hydrant is perfectly efficient for the work we want it to do.

The argument has been made that the 4-in. valve hydrant can be made so there will be less loss by friction. That is probably true, but it would be well for us to take that up with the manufacturers of hydrants, but I don't think we should try to club them into line by penalizing them in that way.

There was another matter that some members of the committee thought was important, and that was that the underwriters should take a little of their own medicine; that they should penalize the demand for an over-large fire supply, or for very small main supply, but they have not quite seen that yet; but I think when they consider the great problem as a whole, rather than little portions of it, they will find that of importance.

I do not think it benefits the underwriters, any more than it does the city or taxpayers of any city, to have a factory which is willing to put in considerable money for a large sprinkler plant, designed by the experts of the underwriters so that they will be perfectly protected — I don't think it is of advantage to the city as a whole, nor the underwriters as a whole, to do that at the expense of the neighbors along the line. You can so arrange your water service that you can only protect one building, and leave all the others in the neighborhood crippled, and that is what the sprinkler men are liable to do, and they do it at the request and the demand of the underwriters' agent, and he puts on the penalty right away, because, if the city refuses to give the water service he demands, he penalizes the building right away, and shoots the insurance rate up.

So we are convinced that matter should have more attention; but the general idea of this grading scheme, we believe, is good. While in some cities we may get the bad end of it, and our water department get a very severe criticism, the man who does good work and has behind him good men, and means to put up a good water department, will get credit. That is all any of us ask. If we are unfortunate enough, through lack of means, or lack of ability, to be doing poor work, we must take our medicine. If

we are fortunate enough to have the ability and the means to do good work, we naturally want the credit. That is what we will get through this grading scheme when it is completely worked out and accepted by the underwriters' agents as a whole through out the country.

MR. R. W. WIGMORE.* I feel that this grading scheme is a move in the right direction. I know at the present time the National Board of Fire Underwriters have been doing this very work in St. John. While the city of St. John a few years ago expended a large amount of money on the extension of their water system, they have got very little return from it from an insurance standpoint. I believe in St. John to-day we are in a very good position, from a water-works standpoint. We have a very large number of three deckers, which is a very great hazard. We have no very good laws in connection with the electric wiring of buildings, and, on account of that, the insurance rates to-day in St. John are perhaps not any higher than they should be, looking at it from the building standpoint and from the wiring of the buildings. No insurance rates are reduced. They admit that our water department is in a fairly good position, but yet the insurance rates have remained the same for a number of years, — and in fact to-day there is talk of increasing them.

Now, from the standpoint of laying larger mains for sprinkler systems, we have endeavored during a number of years to limit the size of mains running in for sprinkler systems and supplies to 4 in., but there has been a demand during the last few years to increase that to 6, and, in fact, in one case this year they were asking for 8-in.

We have discouraged that, although in a few cases we have allowed the 6-in. To overcome that, and to make it safer, we insist that a regulating valve in the standpipe shall be placed on the curb, just in the same line that the hydrant is placed. The hydrant man of the department responds to all alarms. He has a team at his disposal; he gets on the scene of the fire as soon as the fire department. His first duty is to look after the fire hydrant, to see that everything is in good shape. After that, he watches the progress of the fire; if it is in a building where sprink-

* Water Commissioner, St. John, N. B.

lers have been installed, just as soon as he sees that the sprinklers are practically out of business, or of no more use, he goes to the regulating valve on the curb and shuts off the sprinkler system from the building. That is of some use. Some might say, "Well, the walls might fall." We don't let it get that far until the walls fall and prevent him from getting at his regulating valve.

I think there is one thing that the National Board of Fire Underwriters should try and discourage. That is, they should insist that no supply lines larger than 6 in. should be allowed in the sprinkler system.

THE APPLICATION OF COAGULANT INTERMITTENTLY IN EXCESS AMOUNTS AT SPRINGFIELD, MASS.

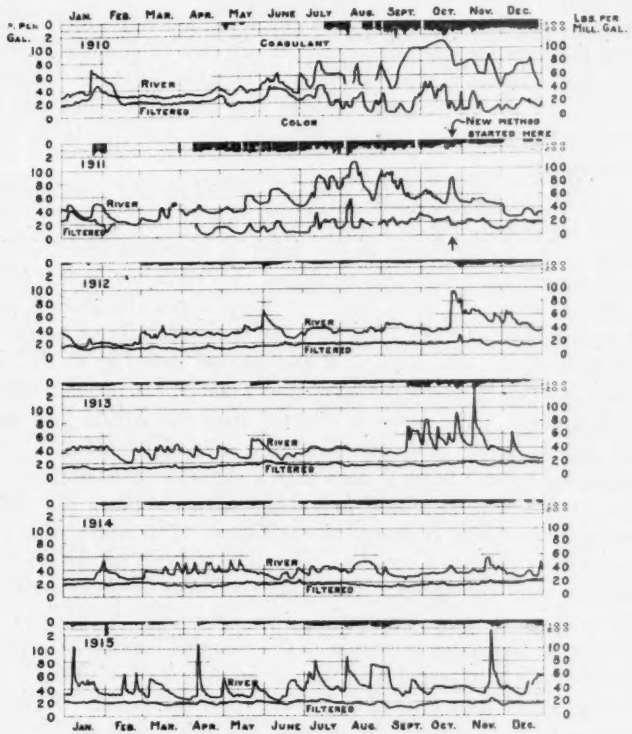
BY ELBERT E. LOCHRIDGE, CHIEF ENGINEER, SPRINGFIELD WATER WORKS.

[*Read September 13, 1916.*]

Coagulation by sulphate of alumina prior to slow sand filtration has been the practice at the West Parish Filter plant of Springfield, Mass., since its construction. Records are now available covering six full years. During the last four years of this time the method of application has been so altered that materially reduced amounts of coagulant are necessary, although at all times it has been possible to produce satisfactory water. This method has been the application of over-doses of sulphate of alumina to the water intermittently. The filters, six in number, are of the slow sand type and of one-half acre area each. The water of Little River as it comes to the filters is that of a mountain stream usually clear, of low alkalinity, but with a varying color, which with the rise of the stream may increase several fold within a few hours. The color in the river water may be low enough for use without any reduction for a long period of time, when suddenly a rise in the stream will cause a large increase of color which makes the water objectionable for use.

A chart is presented with this paper (Fig. 1) on which are two lines, the upper of which represents the color of the river water day by day, and the lower the color of the filtered water at the same time. These are plottings of daily results. The amount of sulphate of alumina in terms of both grains per gallon and pounds per million gallons is plotted above the color lines in such manner that the amount applied each day may be readily seen. This chart gives the comparison of the two-year period of 1910 and 1911, during which time coagulant was applied in the usual manner, with the years 1912, 1913, 1914, and 1915, in which the method to be described was used. The records for the six years are plotted in such manner that seasonal comparisons are also possible.

It is a well-known principle that it is necessary to apply enough sulphate of alumina to secure a complete reaction if the coagulant is to be of value in quickly clarifying the water. If, for example,



WEST PARISH FILTERS
SPRINGFIELD MASS.
COAGULANT-GRAINS PER GALLON-POUNDS PER MILLION GALLONS
COLOR-RIVER AND FILTERED WATER

FIG. 1.

on a certain day one grain of sulphate of alumina per gallon is necessary to secure a complete precipitation or reaction and decisive reduction of color, nine tenths of a grain will not secure nine tenths or even five tenths of the same result. It is nec-

essary to apply the coagulant at least in the amount or rate necessary for this reaction point. It is, therefore, necessary to determine each day the amount of sulphate of alumina which is necessary to secure this clean-cut reaction. In 1910 and 1911 the amount thus determined as the least amount which would bring good results was the amount of sulphate of alumina applied that day. In the method adopted in October, 1911, and carried through all the subsequent records, this critical amount was as carefully determined, but a different use was made of the information.

A brief description of the general conditions and arrangement of the plant will help in the understanding of this process at this point. The Little River at the point of diversion has a catchment area of forty-eight square miles. Its elevation at this point is 496 ft. above sea level, and with steep slopes the ground rises to an elevation of from 1 500 to 1 700 ft. at the highest points of the watershed. The surface of the storage reservoir on Borden Brook is 1 070 ft. above sea level, and 1 000 ft. above Main Street in Springfield. The water is diverted from the stream in a deep and narrow gorge, and sent through a mile of tunnel to a sedimentation basin 8 acres in area with a capacity of 40 million gallons, or between three and four days' supply. From this small reservoir the water is drawn to the filters. The water from the tunnel is carried by a concrete conduit to an arm at the greatest distance from the outlet. There are no baffles or other artificial obstructions in this reservoir. The coagulant is applied in solution to the water in transit in the concrete conduit at a point which causes it to travel with the current 540 ft., permitting some mixing before its submerged delivery into the basin. Water is constantly flowing from the river to this basin through the conduit and is drawn uniformly from this basin to the filters.

The determination of the amount of aluminum sulphate necessary for complete reaction is made in a series of two-gallon bottles from fifteen to twenty in number, which are filled each day with the river water. To these are added, in uniformly varying increments, definite amounts of sulphate of alumina. For example, to the first bottle enough is added to give the effect of the rate of 50 pounds per million gallons; to the next, 60 pounds; to the next,

70 pounds, and so on by ten pounds per million gallon increments to 270 pounds. Within a few hours all of the bottles with amounts of coagulant in excess of the " reaction point " will indicate complete color removal, and the precipitation of foreign matter will be complete, while all bottles containing less coagulant than this amount will be in a cloudy or murky condition, indicating incomplete reaction. The determination is made in this manner each day, permitting a study of the effects of the rise and fall of the stream, the effect of storms, melting snows, etc. This information is also of great value at times of sudden changes, when there is insufficient time to make the determination. The amount necessary is dependent on a number of different conditions. With waters of the same alkalinity there may be quite a marked difference in the amount necessary for reaction, varying with river conditions. It is not entirely dependent on the amount of color, as with the same color to be reduced it varies on different days. The amount of coagulant actually applied to the water is always a little in excess of the reaction point determined, and during the period of application this is kept as nearly constant as possible.

With the amount or rate of coagulant application per hour thus known, it is still necessary to determine the number of hours per day during which it shall be added. Throughout most of the year, from four to six hours per day is sufficient, but at a time of flood, resulting in a very material increase in color, this period may be lengthened to twelve hours, or 50 per cent. of the time.

Generally speaking, the standard set for filtered water is that of no coagulation if the color does not exceed 25. Before the filtered water reaches this figure, coagulant is resorted to, and during such application the color is to be kept at 20 or below. By referring to the accompanying diagram it will be seen that, since the adoption of this method, it has been possible to make the line of color in the filtered water substantially straight or uniform throughout the year; the consumer thus becomes accustomed to a water of low and definite color and never sees water of high color at any time. Under the old method of constant coagulant use, it was found impossible, especially at times of low alkalinity or sudden changes, to add sufficient sulphate of alumina to reduce the water to a satisfactory color at all times. The addition of

soda ash or lime was necessary for restoring alkalinity at such times. This is entirely unnecessary with the intermittent application, as but a small portion of the alkalinity is used in the formation of the floc. The first coagulation in the conduit and basin results in a water of substantially zero color, with at least a theoretically slightly acidic reaction. This treated portion of the water, which has entered the basin chemically active, with the precipitate or floc forming rapidly, is then followed by untreated water in a quantity, because of the longer period of time, in excess of the treated water. The thorough mixing of this raw water with the treated water is brought about at the outlet of the submerged conduit as it displaces the basin water at this point. The second reaction begins at once and is carried to completion with a restoration of alkalinity to the entire supply, this action probably being consummated during the period which elapses before the next application of coagulated water. The floc of the treated water has not had an opportunity to settle when the raw water is admitted, and readily furnishes a base about which the additional precipitation resulting from this secondary reaction forms, and serves to carry down color, sediment, and bacteria mechanically, as well as through the chemical reaction which is taking place in every part of the untreated water as it mixes with the overdosed water. The resultant reduction of color is, therefore, due to the effect of dilution of the higher colored water with water of no color; to the second reaction, which is, in reality, the completion of a reaction started under favorable conditions of overdosing, and which reaction chemically is always complete, as the excess of the applied coagulant is taken up by the alkalinity of the untreated water, resulting in the completion of the mass reaction; and also to the mixing of the floc of the fully treated portion with the mass of the entire day's water supply, before it has the opportunity to settle. The precipitate thus formed in a large part settles before it is carried to the filters.

The sedimentation basin was drawn off and cleaned after five years' operation of the filtration plant, and it was found that large masses of precipitated organic matter and aluminum hydrate had settled in the upper portions of the basin. This deposit covered the entire basin, varying from three to four feet in depth

near the inlet to a few inches in proportion to the distance from the point of entry to the basin of the raw water.

The average length of filter runs during the four years described in this paper of the use of this process were as follows:

Year.	Filter Runs after Scraping.			Filter Runs after Raking.		
	Number.	Average in Millions of Gallons per ½-acre Bed.	Maximum Runs in Millions of Gallons.	Number.	Average in Millions of Gallons per ½-acre Bed.	Maximum Runs in Millions of Gallons.
1912	22	76	90	26	76	84
1913	22	95	115	23	79	91
1914	26	85	152	24	77	157
1915	29	89	229	21	42	104

In conclusion, it may be said that the use of intermittent coagulation results in a saving in expense, uniform results of satisfactory quality, coagulation without exhausting alkalinities in soft waters, and coagulation without excessive overloading of the precipitated hydrate on the filter beds.

SOME ADVANTAGES OF A CLASSIFIED CASH-BOOK.

BY ALBERT L. SAWYER, WATER REGISTRAR, HAVERHILL, MASS.

[*Read September 15, 1916.*]

When I was asked to prepare a short paper on some branch of water-works accounting, I accepted with alacrity, but only from a grave sense of duty towards my fellow registrars and treasurers, as I felt that we had too long permitted our light to be hidden under the proverbial bushel. Looking over the programs of the meetings of the Association, I find very little space taken up by the office section, and yet we are really quite an important part of the organization of a modern water-works system.

The superintendents, engineers, and other experts map out the campaign like generals of an army, and we see the result of their plans in the shape of extensive works, reservoirs, and filtration plants; most of the credit for the success of the plant goes to them, and justly so; but the poor registrar, like the man behind the gun, has his work to do to make the victory possible in collecting the bills and seeing that the sinews of war are at hand, to say nothing of the exciting life that he leads getting the complaints over the telephone, excusing the acts of omission and commission of the superintendent, and acting as a general buffer between the operating department and the public.

It therefore seems that in all fairness we ought to be allowed occasionally to tell our problems and troubles and take counsel together in an endeavor to obtain the best results from our labors. I think that each office has its own peculiar conditions and methods, and, as I do not know the system that any of my colleagues are using, I may be offering nothing of value or that is not already known to you. What I propose doing, then, is to state briefly my own case; the conditions as I found them, and an outline of the methods which I have found practicable and workable, with special reference to the use of a classified cash-book. No matter how good we think our own system is, we may each of us get some new ideas from a discussion of the papers to be presented.

Our present municipal slogan is, " Hitch your heart to Haver-

hill," and all loyal citizens — either as members of our Chamber of Commerce, the Rotary Club, or as plain everyday citizens — are bound to announce that they represent a beautiful and rapidly growing city of 50 000, situated on both sides of the Merrimack River, covering a territory as large as Lawrence, Lowell, and Lynn combined; the largest slipper city in the country, and with various other industries housed in modern and up-to-date factories.

As a water-works man, it is perhaps needless to add that we have the best and purest water of any city represented in this Association, supplied from five lakes and a storage basin; and that our rates are low and our service good.

Haverhill was the first city in the East to adopt the commission form of government, and we are one of the very few cities that has adopted modern charters where the water board was continued without change as a part of the municipal machine; a condition which I believe is correct and makes for greater efficiency. Every man who can get enough votes to be elected an alderman is not capable of running a modern water plant.

Under the act of 1891, creating the water department, it was provided that it be entirely separate from the other departments; hence we collect our water rates, handle the money and pay our own bills; the money being spent by the water board with certain limitations provided in the legislative Act.

I had worked with the former registrar for a good many years, and on succeeding him I kept on the bookkeeping in much the same way that he had handled it. We used to have a sheet of foolscap ruled off by hand, on which we entered our daily receipts as taken in. At the close of the day these were copied into an ordinary sized cash-book ruled with five columns. At times when business was good, we used to balance this cash-book daily; and at less frequent intervals during other seasons. We would perhaps strike balances eight or nine times a month. We also used what we called a classified cash-book, and in this the receipts were summarized covering the same number of days as the smaller cash-book. All payments were entered as in the smaller book. This classified cash-book had more columns than the small one, but many items had to be entered in a sundry column and had to be picked out for the monthly report and to charge in the ledger.

Our new charter provided that the accounts of the city should be audited by a competent accountant (this in addition to the audit by the city auditor), and four years ago this work was given to the Bureau of Statistics, who have done the work each year since. The statute under which this bureau makes audits of municipal accounts places the initiative entirely with the cities and towns, and at the present time 17 cities and 53 towns are taking advantage of the Act. As in all matters of this kind, the Bureau thinks that its system is the only one, and they propose a hundred and one things that make for more books and more expenditure of time and money. On the other hand, they have furnished me with some very practical ideas which I think have helped in a more intelligent classification of our accounts.

The auditor at once said to me, " You are spending all your time copying over lists of names that serve no good purpose and make for errors; get one cash-book ruled to carry most of your accounts, take a balance each day, but actually balance the cash-book only at the end of the month. You will thus save all this duplication, and your footings will show at once what each subdivision has taken in or expended for the month."

The suggestion looked good to me, and I planned out my present cash-book and have used it since, and find it highly satisfactory, and look back with sorrow on the time wasted through sixteen years.

The pages of the debit side of the cash-book are yellow and take about fifty entries to a page, both sides of the page being used. Those of the credit side are of white paper, printed on but one side, and at the close of the month these are bound in the cash-book following the debit sheets.

We have a stub covering every receipt, and these are entered in the cash-book at the close of each day; the cash is balanced daily and the result entered in a small book also suggested by the Bureau of Statistics.

The debit side (Fig. 1) keeps the receipts from water all at the left, with the amount of the bill in the first column; then abatements, discounts, and the amount of cash actually received entered in the column where it belongs. These five columns added together must agree with the total assessment column. The other receipts are entered in the columns set aside for them.

HAVERHILL WATER WORKS — RECEIPTS

Date	Name	Total Assessment	Abatements	Discount	Meters	Haverhill Fixtures	Bradford Fixtures	Other Years	Services	Bldg. Pur.	Rents	Interest	Real Est.	Iron Pipe and Specials	Old Material	Sundries		Cash on Hand

Fig. 1.

HAVERHILL WATER WORKS — PAYMENTS

Date of Bill	To Whom	Ledger Page	Voucher No.	Amt.	Construction.				General Maintenance.									Cash on Hand
					Mains	Services	Meter	Spec. Const.	Mtce.	Current Ex.	Stable	Kenoza Pump Sta.	Millvale Pump Sta.	Bradford Pump Sta.	Meter Mtce.	Crystal Lake Mtce.	Real Est. Mtce.	Sundries	

Fig. 2.

For the credit side (Fig. 2) I tried to arrange a cash-book that would clearly separate construction and maintenance accounts, giving so far as possible a column to each account; using similarly itemized vouchers for payments and a "distribution-book," such as is used by our city auditor, in which to enter the various items at the end of the month, the whole scheme having in view the annual report at the end of the year. This report has exactly the same subdivisions as cash-book, vouchers, and distribution-book, so that the making up of the financial part of the report takes only so long as it takes to add and verify the footings of the distribution-book.

Our cash-book is loose-leaf and, while I arranged it for my own needs, I utilized many valuable suggestions of the Bureau of Statistics. The binder is known as the Kalamazoo, which I would highly recommend as easy to handle, and especially as doing away with the post, which to my mind is a great drawback to most loose-leaf systems. This binder, made of pigskin, stands hard usage and we use it not only for the cash-book but for the register of water-takers. A desk-pad that just holds the loose cash sheets is used for the daily entries and is most convenient, the sheets being bound in the cash-book at the end of the month or oftener if necessary. The advantages as I have found them are:

1. Each receipt and expenditure entered in detail.
2. The items classified as entered.
3. A compact book with no wasted pages.

One of the first things I did after taking charge of the office was to introduce a voucher system. As I said before, we pay our own bills, and these are never sent out of the office with the check, but instead, the voucher (Fig. 3) containing the items of the bills paid, together with a receipt on the one side, and on the other, subdivisions of construction and maintenance, each subdivision itemized as it will later appear in the annual report. As the bills come in, they are checked and classified and the division of the plant to which they are to be charged is stamped on the upper right-hand corner of the bill. When paid, the voucher number is added and the number is also entered on the stub of the check-

book. We are never troubled with lost bills; the vouchers all come back, and the city auditor tells me that it has reduced the time used in checking up the payments in a manner that is satisfactory to him.

I regret to add that the Bureau of Statistics does not wholly approve. First, it thinks the city treasurer should pay the bills; second, it favors a voucher check. I hang to my voucher system, but keep my canceled checks well arranged for emergencies. At the end of the month, after our cash-book is balanced, the clerk goes through the vouchers for the month, bringing together in a book all similar items. These are then entered in our distribution-book. As I said before, our annual report follows the same plan and is simply a summary of the distribution-book.

In our ledger we carry the usual accounts of mains, services, etc., posting from the cash-book footings at the end of the month.

One other thing that the Bureau of Statistics called to my attention was what they call, I believe, a "master account." Previous to adopting this account I regret to say that we simply recorded our receipts, kept track of our unpaid water bills, and trusted we were getting all that belonged to us, but with no exact

HAVERHILL WATER WORKS.
HAVERHILL, MASS.

To *Fred F. Spinney,* Dr. { Voucher No. *287*
Address, *Boston, Mass.*

1916

Date		ITEMS	Amount	
July	*17*	*Bill rendered*	*$31*	*50*

$ *31.50* Dated.....

Received of the HAVERHILL WATER WORKS
the sum of *Thirty-one* and *50/100* Dollars,
in full for the above account.

Signature.....

Per.....

☞ Please Date, Sign and Return this Voucher at once in Enclosed Envelope without Refolding.

FIG. 3. Reverse.

Voucher No. *287* Amt. $ *31.50*

HAVERHILL WATER WORKS

CONSTRUCTION				*(Kenoza Pumping Station)*			
(Mains)				Salaries			
Iron Pipe and Specials				Extra Labor			
Gates and Gate Boxes				Fuel and Cartage			
Lead, Packing, etc.				Telephone			
Freight and Cartage				Repairs and Tools		*3*	*50*
Pay Rolls				Freight and Express			
Sundries				Oil and Supplies			
				Sundries			
(Services)							
W. I. and Lead Pipe				*(Millvale Pumping Station)*			
Valves and Boxes				Salaries			
Oil, Gas, Wood, etc.				Extra Labor			
Freight and Cartage				Fuel and Cartage			
Pay Rolls				Telephone			
Sundries				Repairs and Tools			
				Freight and Express			
(Meters)				Lighting			
New Meters and Fittings				Oil and Supplies			
Pay Rolls				Expense of House			
Freight and Cartage				Sundries			
(Special Construction)							
(Land Account)				*(Bradford Pumping Station)*			
				Salaries			
GENERAL MAINTENANCE				Extra Labor			
(Repairs on Mains; Tools; Maintenance)				Fuel and Cartage			
				Telephone			
				Repairs and Tools		*8*	*40*
Fuel, Oil, Salt, etc.				Freight and Express			
Pay Roll, Maintenance				Oil and Supplies			
Pay Roll, Maintenance M. P.				Expense of House			
Pay Roll				Sundries			
Tools and Repairs		*7*	*10*				
Repair Material, etc.							
Sundries				*(Real Estate Maintenance)*			
(Current Expense Account)				Pay Roll			
Salaries and Clerical hire				Repairs			
Stationery, Printing, Postage, etc.							
Telephone				*(Meter Maintenance)*			
Lighting							
Rent and care of Rooms				Reading			
Office Furnishings and Fixtures				Repairs			
Sundries				Express			
(Stable Account)							
Hay and Grain				Crystal Lake Mtce			
Horse Shoeing				Kenoza Lake Mtce			
Horse Hire				Round Pond Mtce			
Rent				Lake Saltonstall Mtce			
Automobile				Johnson Pond Mtce		*12*	*50*
Sundries				Chadwick Pond Mtce			
				Reservoir			

FIG. 3.

knowledge as to whether the yearly assessment was accounted for or not.

I now start the financial year charged with so much in unpaid bills of various kinds; I then charge myself with the assessment for meters, fixtures, labor bills, and all other bills sent out (Fig. 4). I am credited with abatements, discounts, and cash receipts; and these with the unpaid bills must total the same as the debit side.

ALBERT L. SAWYER * WATER REGISTRAR

In account with HAVERHILL WATER WORKS.

DR.		CR.	
Unpaid bills November 30, 1914	$2,905.30	By Cash receipts	$158,225.84
Water Assessment	178,127.19	„ Abatements (water)	3,582.35
Labor bills	19,502.71	„ Abatements (services)	110.03
Rents	1,209.08	„ Discounts	42,487.08
Interest	918.25	„ Unpaid bills (water)	75.69
Town of Groveland	1,126.00	„ „ „ (services)	1,942.71
Sale of wood	2,303.87	„ „ „ (rents)	13.00
Miscellaneous	344.30		
	$206,436.70		$206,436.70

FIG. 4.

We take a test balance each month except at water-bill time, when we have to take two months at once, and if we don't come out right, we have to dig till the mistake is found.

So many errors will creep in, one sometimes balancing another, that I believe this is a most accurate way of keeping things straight. We have had to go over thousands of stubs at times to find an error, but it is certainly a satisfaction to know that every cent is accounted for, while the fact that it must come right, and that errors must be found, is an incentive to the office clerks to be accurate.

As I had occasion to point out in a paper read at a previous convention of the Association, Haverhill has one of the oldest water-works plants in the country. I have brought with me the old cash-book of the Aqueduct Company, showing the first entry made in 1802, so that those who wish may compare the simple bookkeeping of the ancients with the somewhat more complex system demanded by present-day ideas as exemplified by bureaus of statistics, civil service commissions, and other supervisions foisted upon us by the paternal government of the old Bay State.

NOTE. — Discussion of this paper will be found on page 66, following the paper by Mr. Pride.

WATER-WORKS ACCOUNTING.

BY EDWIN L. PRIDE, CERTIFIED PUBLIC ACCOUNTANT.

[*Read September 15, 1916.*]

Mr. Fred G. Reusswig, in dealing with Uniform System of Accounting for Cities, says:

"Proper accounting does not of itself produce efficient administration, but it is generally conceded that proper accounts are essential to effective administration, to intelligent planning, and to sound appraisal of the results obtained. An adequate system of accounts in a city makes available, to the officers thereof, knowledge of the important facts relating to the cities' operations, and of the cost and efficiency of their administration, and, if the same system is used by a number of cities, makes possible the securing of trustworthy comparisons between cities, thereby increasing efficiency by placing a statement of the results obtained by one city before the officers of others so that all may profit by the experience of each."

I believe, therefore, that we are safe in starting off with the assumption that the advantages of uniform accounting are conceded. But, the minute we attempt to leave the starting point, we are confronted by obstacles in the form of differences of opinion as to how far we may go in the development of an accounting system without making it too complex for the fiscal officers of the smaller municipalities. In some places, the salary of the chief fiscal officer is so small that he cannot devote his entire time to his public work, and an involved system of recording transactions would take more time than he can afford to give. It also happens frequently that the chief fiscal officer, who is also the accounting officer, is selected because he is a man of known honesty, and the question of his ability to handle accounts never enters into his selection. These conditions alone give embarrassment to any one attempting to devise a practicable accounting plan, and the perplexities are multiplied when we come to consider the dissimilarity of financial provisions of various city charters. To over-

come these obstacles requires both skill and courage on the part of the accountant who undertakes the task.

The purposes of good accounting are to give information of the operations and reflect its financial condition. But, in order to do this, it is necessary that the accounts show the accurate and complete record, and this can only be done by adopting the accrued basis. Recording only sums received and sums paid out, without any reference to revenue which the city would receive, or the expenditures which it would have to meet, which would include not only amounts paid out but amounts of obligations incurred and not yet paid, is wrong.

In respect of revenues, the accruals are taken into account in the proposed system by setting up asset accounts for all accruing revenue items, and crediting them to revenue regardless of actual collections. As to appropriations, the proposed system requires that all orders, contracts, and claims, in other words, all encumbrances and commitments, shall be recorded on the books of the city and charged against the appropriation. This, together with the proposal of an inventory of material and supplies at the end of a year, makes it possible to ascertain the amount of expenses incurred during the year.

It will establish for each city standard accounts for revenues and expenses, so that the classification thereof will be uniform during all administrations, thereby enabling comparisons of expenses and revenues between years.

I do not know of any better "Uniform Classification of Accounts for Water Companies" than those prepared under the direction of the Public Utilities Commission in the state of Maine which were made effective July 1, 1915, and their instructions regarding each and every account are ideal to my mind; but I would like to call attention to one item — that is, what they say regarding

"W332. DEPRECIATION AND CONTINGENCIES.

"This account shall be charged periodically an amount, estimated or determined by some method prescribed by the officials of the corporation, which shall be sufficient to cover the cost of future replacements of tangible property, made necessary on account of gradual wear and tear and obsolescence and inadequacy

as have accrued during the period of such property, any portion of the intangible capital as may have expired during the period, and the amount estimated to be necessary to provide a reserve to cover the cost of property destroyed by extraordinary casualties. Amounts charged to this account shall be credited to the account known as ' Reserve for Depreciation.' "

I have testified as an expert in a great many water-works court cases, and I have maintained that a flat rate of two per cent. of the value of the water system (allowing fifty years for the life of it as a whole) annually is a fair charge against the income.

My friend Harvey S. Chase, certified public accountant of Massachusetts, said, — and others have said the same thing, — and I believe you all agree (though you may differ with me on the rate or the method of depreciating),— rates cannot be just unless full allowances shall have been made for deterioration of the plant, or, in other words, for the capital losses which arise from depreciation, such losses must be provided from income, or otherwise they will require new capital. Therefore they should be handled in the accounts as regular charges against income.

Whenever depreciation is made good by actual expenditure for renewals or reconstruction, such amounts should be charged against the reserve for depreciation, and the balance remaining in this account will show whether or not the sufficient allowances are being made year by year to provide for depreciation losses.

Auditors, comptrollers, and managers are seeking for light upon this subject, and all men who make studies of municipal affairs become convinced of the necessity for uniform and standard methods for handling depreciation which should be identical in, and mandatory upon, both public service companies and municipal enterprises.

If we leave the allowances to be made for depreciation to be estimated or determined by officers of the corporation, I am afraid, in comparing the different returns, we would find them to be anything but uniform.

I am not " fussy " as to the bookkeeping, whether accounts should be kept in bound ledgers, loose-leaf ledgers, or on cards. There are good arguments in favor of each; but I am particular as to the accounts.

One general "plant account," representing all the land, buildings, reservoirs, dams, distribution mains, meters, services, equipment, etc., and one general "expense account," are not what I would recommend. An up-to-date system of accounts to-day must be one that can clearly and quickly answer any and all questions.

The plant account must be divided so that we will know what makes up this account to a unit. The revenue and income must be segregated so we can know from what sources they are derived. The expenses must be kept almost minutely. These are essentials in the management of any business or operation of any water works.

When these results are obtained, then we have something that is helpful, and comparisons are valuable.

Discussion.

Mr. Walter P. Schwabe.* I feel that the introduction of Mr. Sawyer's paper is very important to this Association. I believe the accounting part of the water department companies has been sadly neglected as to its standing and the place it occupies. A proper system of accounting is of vital interest in the management of our business. It gives us figures for comparison, so that the engineers or executive can find out what they are doing in relation to similar work in other parts of the country, or other companies in the same state.

The present requirements of utilities commissions and bureaus of statistics mean a considerable amount of work, as far as accounting is concerned; and it will be well for water companies to unite on certain classes of uniform accounting, so that these bureaus and utility commissions, when they are looking for certain information, can get it, without each utility commission forming its own classification, or each bureau of statistics, and every one reporting in a different way, so that there is absolutely no chance for any comparison whatever.

I trust that these papers, this presentation here, will lead to the appointing of a committee by this Association. I think that

* President and General Manager, The Thompsonville Water Co., Conn.

is absolutely necessary. Much can be accomplished by an accounting committee, and you will find utilities commissions will confer with them in formulating their accounts. It has proven so, in the case of electric and gas utilities. The accounting committees of these national organizations are very important, and in their meetings in recent years one day has been set aside for accounting systems. From that point of view, I believe these papers are perhaps the most important we have had during this session, and I trust they will lead to the appointing of an accounting committee that will be permanent.

MR. S. H. MCKENZIE.* I wish to second what the gentleman has said in regard to accounting, from some little experience I have had, especially in one of the small companies in Connecticut, where I have come to realize the great importance of it. Our public utility commission recently got out an order requiring quite extensive reports, and a great many of our smaller companies were not in a position to answer or fill out those reports. So I got up a set of books for the one small company with which I am connected; and, in order to save expense for ourselves, I got them up in such a way that they could be used by other companies, and have introduced them in several different places. In one place, for instance, when I came to take the books of the company and try to make up the report, I found they had simply a cash book, and they couldn't tell whether they were making or losing money, and were surprised, when the report was made out for them, to find that they were going in the hole each year. That one incident alone, though there are others, makes this matter to my mind very important, and I hope that the Association will appoint a committee to study further into the matter and see if a uniform system cannot be gotten up; and, if such a committee is appointed, I think they should consider also the smaller companies. They are not in a position financially to adopt the expensive systems which the larger companies are using, but must have something which will answer their needs.

We are using a simple form of cash book in which the items are all entered, and then, at the end of the year, — and sometimes at the end of six months, depending on the size of the company, —

*Engineer and Superintendent, Water Dept., Southington, Conn.

SHEET No._____ WATER WORKS DEPARTMENT

RECORD OF RECEIPTS IN MONTH OF *19*

Day	From	Pays	Credit: Acct. No.	Misc.	Forfeits	Accts. Rec.	Water Rent	Deductions: Acct. No.	Water Rent Vac.	Acct. No.	Misc.	Net: Amt Rec'd	Amount: Date	Deposited
	Brought Forward													

DISBURSEMENTS SHEET No.....

Record of Checks Drawn on.....in Month of.....191....

Date	To Whom Issued	Pays	Charge Acct. No.	√	Detail	Amount	√	Check No.	Deposits: Date	Amount	Balance
	Amounts brought forward.										

FIG. 5.

RECEIPT AND DISBURSEMENT SHEETS USED BY SEVERAL SMALL WATER DEPARTMENTS IN CONNECTICUT.

.....WATER CO.....CONN.

FINANCIAL STATEMENT FOR *ENDING*

ASSETS				LIABILITIES			
No.	Account	Detail	Total	No.	Account	Detail	Total
C-1	CASH: Nat'l Bank			20	Capital Stock		
C-2							
C-3				22	Bonds Issued		
C-4	Funds Advanced						
B-1	BOOK: Water Rents Due			24	Notes Payable		
B-2	Accounts Receivable						
B-3	Notes Receivable			26	Accounts Payable (Current)		
M-1	MATERIAL: Construction Supplies						
M-2	Tools			28	Interest Accrued (but not due)		
1	PLANT & EQUIPMENT: Organization						
4	Water Collecting System						
6	Pumping System						
7	Distributing System			30	Reserve for Depreciation		
8	General Structures						
9	General Equipment			32	Reserve Account		
12	Engineering & Superintendence			35	Surplus (Profit and Loss)		
13	Law Expenditures (Const.)						
14	Injuries (,,)				Total Liabilities		
15	Taxes (,,)				Current Net Gain		
16	Misc. Construction				Total		
17	Interest during Construction						
					MEMO.		
					Surplus on.....		
4-A	NEW CONST.: Water Diversion Rights				Current Income & Expense		
4-B	Reservations				Interest Received		
4-C	Imponding Dams and Res.						
4-E	Springs & Wells				Interest Paid		
4-G	Collecting Cond. & Res.				Dividends Paid		
4-H	Gravity Intakes & Suction Mains						
4-I	Supply Mains				Present Surplus		
6-A	Pumping Station						
6	Pumping Equipment						
6-F	Misc. ,, ,,				TRIAL BALANCE	DEBIT	CREDIT
7-A	Transmission Mains				Assets		
7-B	Distributing Reservoir, Tanks				Liabilities		
7-C	Distributing Mains				Sales		
7-D	Service Pipes, &c				Miscellaneous Gains		
7-E	Meters				Operation		
7-F	Fire Hydrants				Maintenance		
					Salaries		
					Office Expense		
					Miscellaneous Expense		
					Interest & Dividends Paid		
	TOTAL ASSETS						

FIG. 6. FINANCIAL STATEMENT SHEET USED BY SEVERAL SMALL WATER DEPARTMENTS IN CONNECTICUT.

STATEMENT OF SALES AND EXPENSE FOR AND PERIOD ENDING 19

No.	Account	Current Detail	Current	Current Total	Fiscal Year to Date Detail	Fiscal Year to Date	Fiscal Year to Date Total	Last Year Total
40	SALES: Fix. Rates, Dom., Stores, &c.							
41	,, ,, Factories							
42	,, ,, Public Uses							
44	Meter Rates, Dom., Stores, &c.							
45	,, ,, Factories							
46	,, ,, Public Uses							
48	Hydrants, Public							
49	,, Private							
50	Other Fire Protection							
52	Street Sprinkling							
54	Miscellaneous							
	Total Sales							
60	MISC. GAINS: Interest Rec'd							
61	Forfeited Discounts							
62	Miscellaneous							
	Total Gross Income							
71	OPERATION: Collecting System							
72	Pumping ,,							
73	Distributing ,,							
74	Miscellaneous							
76	MAINTENANCE: Collecting System							
77	Pumping ,,							
78	Distributing ,,							
79	General Repairs							
81	Water Purchased							
82	SALARIES: Gen. Officers and Clerks							
83	OFFICE: Rent							
84	Office Expense							
85	MISC. EXPENSE: Taxes							
86	Insurance							
87	Legal Expense							
88	Accident							
89	Uncollectible Accts.							
90	Depreciation							
94	Income and Expense Summary							
95	SURPLUS: (P. & L.) Int. Paid on Bonds							
96	Interest Paid on Notes							
97	Dividends Paid							
100	All Labor (Memo.)							
	GAIN OR NET INCOME AFTER PAYMENT OF INTEREST AND DIVIDENDS							

FIG. 7. REVERSE OF FIG. 6.

they are brought together and made out on a separate sheet. It is a little different from what we use in private companies, but to my mind it is a very simple statement, and places before our board on one sheet of paper the entire profit of the company for one, two, or three years. (See Figs. 5, 6, and 7.)

MR. W. C. HAWLEY.* Mr. Pride has brought up the matter of depreciation. I wish he had carried the matter a little further, but as he did not, I want to ask him a question or two. In the first place, as to the rate of depreciation, I cannot understand how a uniform rate of, say, two per cent. can be applied to all plants. In the first place, there is a question how you are to carry your rate. On a gravity plant, the rate of depreciation will be materially less than on a pumping plant. In a town that is growing rapidly, your depreciation will be much less than in a town whose rate of growth is comparatively small. All these things must be taken into consideration.

In some studies which I have made, I have found a rate on the sinking fund basis to vary from about one half of one per cent. to as high as one per cent., — perhaps one and a quarter would be a fairer rate in that particular case. So, it seems to me, in each case the rate must be determined by an actual study of the units of the plant, applying the proper life and figuring out what the depreciation would be on that basis.

I should like to ask Mr. Pride what his idea is as to how a depreciation reserve fund should be carried. Those of you who are familiar with what has been done by the Association in the Central West, probably know that in many cases where there has been simply a bookkeeping entry made of depreciation, the commissioners assumed the depreciation, instead of having been actually put aside, has been paid to the stockholders. I am speaking of private companies, of course. Therefore depreciation has been subtracted from the value of the plant for rate-making purposes. That is a rather dangerous proposition. If we are to be penalized in that way, it seems to me we have got to be pretty careful, and that probably a better plan would be to actually create a sinking fund, or depreciation fund, putting the money into it, having a really tangible thing, perhaps with a commissioner or trustee,

* Chief Engineer, Pennsylvania Water Co., Wilkinsburg, Pa.

and then that money being invested either in securities, or, in the case of a private company, perhaps, by the company, but invested in construction, the company giving its note to the trustee or commissioner for the amount so borrowed, and paying interest thereon. Then the money, in the case of depreciation calculated on the sinking fund basis, is in the plant. It is simply making up the difference between the percentage of valuation of your plant and one hundred per cent.; and that is, the actual value of your plant and the one hundred per cent. valuation that you started with.

I would like to know what Mr. Pride thinks about the actual creation of such a fund. The Wisconsin Commission has already put forth some very excellent forms of water-works accounting, and doubtless, if a committee of this Association is appointed, their forms can be studied with profit. It will be a very helpful committee, I think.

Just one other matter in the case of a community which has grown very materially. I believe that in many cities a material saving can be made in the matter of meter reading by distributing your readings along monthly, or semi-monthly, as the case may be, instead of trying to read your meters all semi-annually or quarterly, or perhaps reading them all every month. In our plant, where we have some 14 000 or 15 000 accounts to keep, we have divided our territory into districts, and we are reading every two weeks. We read the meters at the beginning of the month. So in two weeks the bills go out, and then the next district. In that way we are able to cover our ground with about one third as many meter readers as we had, and they still have time to do a considerable amount of meter repairing. We do not have a great crowd of people coming to our office to pay their bills. They come along gradually. We are able to handle them with less office help, and we have found it to work out very nicely, and to give us quite a material saving.

MR. SAWYER. Now that we have got the accounting end of the Association started, I wonder if it would not be a good idea to get something in concrete form, perhaps. I think I would make a motion that a committee be appointed on accounting. Possibly, in going over the ground, they could suggest something

that would be of help to all of us in standardizing our accounts. I understand perfectly well the conditions are so different in different places. For instance, Mr. Pride spoke of appropriations in the case of cities. We do not have any appropriations; we simply have all we take in, and spend that; that is, we do not have any appropriations at all from the city.

MR. KING. Some six years ago there was a meeting in Washington, under the direction of the census bureau, at which this matter of accounting in water works was discussed for several days. Prominent accountants from Baltimore, from Boston, and New York, were present, and the matter was thoroughly discussed, and the Government has published a report of the recommendations to that committee, and it will be found in their publication; I think we have one of the reports in the Library.

MR. SHERMAN. The matter which Mr. King has called attention to is one which has not been as widely known among our members, and among water-works men generally, as it should be. The committee, if it can be called a committee, which got together at that time, did a very valuable work, and the publication issued by the Bureau of the Census, formulating the results of that conference, is very suggestive, and contains very much information of value. It, however, has occasionally been put to unfortunate uses, and that is a fact which I wish to call attention to at this moment. That schedule is sometimes quoted as having been adopted by the New England Water Works Association and other associations, apparently from the fact it was formulated by a body of men containing representatives from those several associations. It, however, cannot be too strongly borne in mind by any one having occasion to use it, that, as good as it is, it contains some points which are perhaps still open to discussion, and which never have been formally adopted, — certainly by this Association, nor, I think, by the American Association,— nor has it ever been submitted to them for adoption. It was draughted by the Bureau of the Census, following this conference.

MR. FULLER. If my recollection is right, there was a committee appointed, and they got out a schedule. Whether it was actually adopted by the American Water Works Association, I am

not sure. Certainly a committee was appointed and got out some schedule on uniform accounting.

MR. SHERMAN. Mr. Fuller is quite right on that. The American Association had a committee which took part in the discussion, of which a gentleman who took part in the Washington discussion was chairman. They got out a pamphlet of, I should think, one hundred and fifty pages, giving very detailed statements of the accounts recommended, but I have been unable to find out that the American Association ever did anything with the report. It does not appear in the American Association's publication. They got out this advance copy, which I have had, and which has been very useful, but although I have hunted carefully through the proceedings to find what they did with it, I cannot find that they took any action on the report of the committee, or ever published the report in their transactions.

MR. FULLER. Some of the public service commissions have adopted standard methods of accounting, which are along the general lines outlined in the American Water Works, but very much simpler. My impression is those are compulsory in the state of New Jersey. They certainly have a uniform system of reporting, and I think of accounting, at least for private companies.

PRESIDENT SULLIVAN. I find that public utilities commissions and service commissions take a broad grasp of these things, and include in classifications and uniform accounting, problems that are kindred to some extent, such as gas, water, and electricity. They have large problems. Some of us who get reports to be filled out find that they are very nearly analogous to the gas company or electric light company, or something else. So I think the Association itself would do well by having a committee appointed to study it. We would be the gainers. We would obtain the information they would gather, and use it or not use it, as we saw fit.

MR. BACON. I would like to make a supplementary motion to the effect that the committee take into account the previous investigations of uniform accounting made by other water-works associations, by the Bureau of the Census, and by the various public utility commissions. I would like to make a motion to amend the motion before the house.*

* For the appointment of the committee see JOURNAL N. E. W. W. A., XXX, 513.

MR. SAWYER. I wish to make a suggestion. I think that at some time, at some future convention, it will be very interesting to the water registrar end of it, in particular, if we could have some kind of an exhibit by the water registrars. In other words, suppose each office could come to the convention with a card, or a small sample of their forms. I have found by visiting other offices you get a great many ideas. Some things you can't adopt altogether, but you can get something that is applicable to your office. I think it would be interesting if we could not only have water valves but have a little booth devoted to the registrar, so we could bring down something that we could all come and look over and see if there was anything that we could put into our own offices, which we were not already using.

PRESIDENT SULLIVAN. I think that educational feature is a very good suggestion; and I trust, when the committee is appointed, they can evolve some scheme whereby they can show what they use in accounting.

MR. PRIDE. I wish to reply to the gentleman in regard to his depreciation suggestion, in support of my suggestion of a two per cent. allowance for depreciation, yearly. I use the factor of two per cent. on account of allowing that the life, as a whole, of a water-works structure is fifty years, and I do that so as to get at some basis for uniform accounting.

It is true that no water-works plant, or the soil, or the water in all places is alike, and we cannot have the same depreciation in one place as we get in another place, but if we set up a two per cent. depreciation on the whole plant, and deduct that depreciation from our earnings before any dividend is declared, set it one side, take it out of our earnings and have that to take care of a depleted plant, and then have all our material, — that is, in the way of construction — and replacement charged against that depreciation, we will then see whether or not we are setting aside enough to take care of our depreciation. It is the physical loss that I wish to take care of. The sinking-fund method, almost always, takes care of a lot of bonds that are out. You set aside the cash to take care of those bonds, but there is no provision made to take care of the deterioration of the structure.

I feel that if we adopt a uniform system, we know on a com-

parable basis what all the other water plants are doing, and we can see whether or not they are running on a percentage basis the same as the other plant, or more, and it will be helpful to us, and guide us in our water-works accounting.

Poor old Boston & Maine would never be in the condition it is to-day if depreciation had been taken care of before dividends were declared.

MR. SHERMAN. While the matter of depreciation is under discussion, another word may not be out of place. It is, of course, extremely necessary, in handling water works and other public utilities, to distinguish carefully between annual charges for depreciation and what has been called accrued depreciation, or the loss in value of the plant as compared with its original cost. The latter item is perhaps of not great, certainly not of controlling importance in the operation of the plant, but, in the accounting connected with it, it is of considerable importance at intervals in making any comparison of the actual value of a plant with the indebtedness standing against it, particularly in the case of a private company, but perhaps most so in the case of a municipally owned plant. It is, of course, of immense importance at the time of the appraisal of a plant for purposes of taking by municipal authority from a private company. In that case, it is of great importance to know what the real value of the plant is at the time of taking, and one method of estimating that, commonly employed, is to estimate the reproduction cost, or obtain the original cost as the case may be, and deduct the estimated accrued depreciation.

In operation, it is essential to set aside, as Mr. Pride has so forcibly pointed out, a sufficient sum to cover on the average the loss of value accruing during the year; whether that is done by setting aside year by year a fixed percentage of the cost of the plant new, or whether it is done by some other method, is of comparatively slight moment; as long as a sufficient sum and not an unreasonable sum is set aside. For many reasons, in many cases, it seems to me that the most satisfactory method in accounting for annual charges is to take a fixed percentage of the gross revenue; the revenue, particularly in water plants, is usually reasonably closely fixed, in any particular plant at least, in its relation to

the value of the works. If a definite percentage of that revenue is applied to depreciation reserve, just as a definite amount must be used in the case of a privately owned plant for paying taxes, those charges are taken care of automatically. Of course, you can only tell whether a reasonable sum is being set aside by making an appraisal at intervals of five or ten years and comparing the real value of a plant as it then exists with the cost, and the sums which have been set aside or charged off as depreciation.

ON THE NATURE OF COLOR IN WATER.*

BY THORNDIKE SAVILLE, ASSISTANT IN MUNICIPAL ADMINISTRATION, HARVARD UNIVERSITY.

[*Read December 13, 1916.*]

The writer has been engaged in a study of the problem of color removal from water, and in connection with the experiments which he has carried on, application has been made of some of the newer ideas of physical chemistry. The investigations described herein were undertaken with a view to proving or disproving the colloidal theory of color in water, and the discussion of results and conclusions are largely confined to that problem.

The question of color removal from public water supplies is being studied by many engineers. It is not so much a question of hygiene as of esthetics; not so much a provision to safeguard the health of a community as to cater to that psychological attribute which makes a clear and colorless water *seem* more salubrious than a turbid or colored water.

Present knowledge concerning the nature of color in water is far from satisfactory. From this lack of information there results the use of inadequate and often troublesome methods of removing color from public water supplies. The studies reported in this paper are, therefore, only a contribution to the larger study of color removal, and they are presented as offering possible new departures in the technique of color removal practice.

The investigations made by the writer have been only upon waters from localities along the Atlantic Coast.

The Present Conception of Color.

The origin of the brown color of water is generally considered to be due to chlorophyll or its allied products derived from dead and decaying vegetation. Carbon, hydrogen, oxygen, and iron have been shown to be important elements of the coloring material.

* No. 1 in "Studies on Decolorization of Water," Contributions from the Laboratory of Hygiene and Sanitation at Harvard University.

In general, the greater the amount of iron in a water, the greater will be its color. The color is usually some shade of brown, either yellowish or greenish brown; the change from one to the other often being seasonal.

Until comparatively recently, the physical nature of the color in water has received little attention. It used to be stated that (1)* " color is due to substances in solution, while turbidity is due to substances in suspension." Moreover, (2) " tannins, glucosides, and their derivatives are doubtless present. . . . Carbon is the important element in its composition, and the color varies in amount very closely with the 'oxygen consumed.'" That " coloring matter (in water) is similar to, and possibly identical with, the coloring matter in tea " (1, 2) has been generally accepted as a satisfactory explanation of the character of the coloring matter. These statements represented the current views on the question of the nature of color in water which have been held until lately. Recently studies have been made which will doubtless cause these earlier theories to be somewhat modified.

The belief has been slowly gaining credence that coloring matter in water is essentially colloidal in nature, and does not primarily exist in true solution. It is the aim of this article to show that color in water is certainly in the colloidal state, and that it exhibits definite and characteristic electrical properties which substantiate this contention.

The Nature of Colloids.

To make more intelligible the discussion of the material presented in this paper, a brief résumé of the underlying theory is attempted in the following paragraphs. This is the more desirable since, to the writer's knowledge, no such statement of the colloidal theory as applied to color in water is available, except in two somewhat contradictory articles by Catlett (3, 4).

At the outset it is important to define a colloid. The whole study of colloids is of such recent development that the nomenclature is as yet unsettled and often contradictory. The terms given below have been taken from the latest writers on the subject, and indicate the most recent views.

* Figures in parenthesis refer to titles in the bibliography appended at the end of the paper.

"A colloidal solution may be defined as a suspension, in a liquid medium, of fine particles which may be graded down from those of microscopic to those of molecular dimensions. The one property common to all such solutions is that the suspended matter will remain almost indefinitely in suspension in the liquid, the natural tendency to settle due to the attraction of gravitation being overbalanced by some other force tending to keep the small masses in suspension (5)." It has been shown that nearly all substances exist in the colloid condition if finely enough divided or properly prepared, and hence we now speak of substances as being in the colloidal state rather than of certain substances as colloids. The size of particles to be in the colloidal state is generally taken to be from 0.001 mm. to 0.0000001 mm.

There are two major classes of colloids: (*a*) viscous, gelatinizing mixtures, not readily coagulated by salts, such as gum arabic, gelatine, glue, etc.; and (*b*) non-viscous, non-gelatinizing, readily coagulable mixtures. The first types are known as *emulsoids*, and may be considered as suspensions of one liquid in another liquid, as globules of fat in water. Those of the second type are called *suspensoids*. The latter consist of very finely divided particles in suspension in a liquid, and as color in water is supposed to exist chiefly in such a state, this is the only class of colloids which we shall consider. It is probable that the color in some waters, and possibly some of the color in all waters, is in the emulsoid state. The conclusions arrived at in this paper, however, are thought to be valid whether color in water is conceived of as a suspensoid or an emulsoid colloid.

Color in water is postulated as ordinarily a suspensoid colloid. The colloid particles, though invisible to the eye or under the microscope (colored water is often quite clear), are visible in the Tyndall ray (6). This is a device which makes use of a beam of reflected light passed through the colloid solution. The colloid particles are thereby rendered visible. The phenomenon is similar to that by which dust particles in the air, ordinarily invisible, are made visible in a beam of sunlight. If the illuminated particles be now viewed through a microscope, their character can be ascertained. This combination is known as the ultra-microscope.

It was early found that ordinary suspensoids moved to one or

the other electrode when an electrical current was passed through the liquid. This phenomenon has been called *cataphoresis*. The electrode toward which the suspensoids move is dependent upon the character of the charge which they carry, those negatively charged moving to the anode (and being called anionic suspensoids), while those positively charged move to the cathode (and are called cationic suspensoids). Certain substances when suspended in a colloidal state in water exhibit these characteristics, and in the following discussion it will be well to have in mind certain typical suspensoid members of each class * (5).

"The fundamental assumption is that when a particle suspended in a liquid becomes charged, there exists about it a double electric layer; when the particle is negatively charged, there is a layer of negative electricity on the surface of the solid particle, while in the liquid immediately surrounding it there is a corresponding layer of positive electricity"; and vice versa for positively charged particles (5).

"In regard to the cause and character of the electrification, the phenomenon has been expressed by the term 'contact electrification'; the particles becoming charged by the rubbing of the moving particles of the liquid itself against the suspended particles" (5).

It has long been known that when certain salts such as $Al_2(SO_4)_3$ (the "alum" of water supply terminology) are added to water, a flocculation and precipitation takes place.

Hardy (7) has shown that this is a colloidal phenomenon, the

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* ANIONIC SUSPENSOIDS.

1. Sulphides of arsenic, antimony, and cadmium.
2. Suspensions of platinum, gold, silver, and mercury.
3. Vanadium pentoxide.
4. Stannic acid and silicic acid.
5. Aniline blue, indigo, molybdena blue, eosin, fuchsin, Prussian blue.
6. Iodine, sulphur, selenium, shellac, resin, kaolin, quartz.
7. Starch, mastic, caramel, chloroform.
8. Silver halides.
9. Various oil emulsions.

CATIONIC SUSPENSOIDS.

1. Hydrates of iron, chromium, aluminum, copper, zirconium, cerium.
2. Bredig solutions of bismuth, lead, iron, copper.
3. Hofmann's violet, Magdala red, methyl violet, Bismarck brown, methylene blue.
4. Albumen, hemoglobin, agar.
5. Titanic acid.

$Al_2(SO_4)_3$ forming aluminum hydroxide* which is in colloidal state. He formulates two rules for flocculation by electrolytes, as follows:

1. The coagulative power of a salt is determined by the valency of one of its ions. This preponent ion is either the negative or positive ion, according to whether the colloidal particles move up or down the potential gradient.

2. The coagulating ion is always of the opposite electrical sign to the particle.†

APPLICATION OF THE COLLOIDAL THEORY TO COLOR IN WATER.

If the foregoing hypotheses are correct, and if we can apply them to interpret the nature of color in water, the following facts should be borne out in practice:

(1) If color is due to particles in the colloidal state, and such particles are merely minute masses of matter in suspension, then, given time, we ought to get decolorization by gravity alone. Under ideal conditions of quiescence and constant temperature, such might be the case. Practically the particles are so small, and are influenced to such an extent by convectional currents and wind, that it is quite feasible to keep them in suspension indefinitely by mechanical means alone. Add to this, that if, as we postulate, each particle carries a similar charge of electricity, there is a mutual tendency to repulsion, and in this way also the suspensoid phase is continued despite gravitative influence.

Moreover, as the velocity of a particle falling in a liquid is, according to Stokes (8), given by the formula $V = \frac{r^2(s-s')g}{gn}$ where r equals radius of particle, s equals specific gravity of particle, s' equals specific gravity of liquid, n equals viscosity coefficient, and g equals gravity constant, it will be seen that the velocity of settling is proportional to the square of the radius. Thus in a particle having a size of 10 microns,‡ the size of a gold sol,§ the

* It is now generally considered among chemists that the compound heretofore called aluminum hydroxide is really hydrous aluminum oxide having the formula $Fe_2O_3 + x\ H_2O$, instead of $Fe_2(OH)_3$.

† See footnote, page 91.

‡ 1 micron = 0.001 millimeter.

§ See footnote, page 88.

velocity of settling under the influence of gravity alone and under ideal conditions is at the rate of 10 mm. per month. If, now, "the flocculation of particles increases the effective radius, flocculation must have the effect of greatly increasing the rate of sedimentation and, therefore, of clearing of suspensions (9). This is in fact the chief way in which flocculation is made manifest, and from this fact comes the common use of the word flocculation as signifying the rate of clearing of a suspension."

(2) If the color be due to colloidal particles in suspension, then they should be coagulated by electrolytes and in accordance with the laws of Hardy (page 82). If all the color colloids carry the same charge, they mutually repel each other, and so tend to remain in suspension. If an electrolyte be now added carrying an opposite electrical charge, flocculation should occur. This is precisely what happens in greater or less degree, but in less simple relations.

As the writer hopes to show hereafter, color in water may carry either a positive or a negative charge. When the color is positively charged, it is removed by alum chiefly by mechanical action, and an overdose of alum will be needed to form a heavy enough precipitate to carry down the suspended color particles. In the case of negative color, both the positive aluminum ion from $Al_2(SO_4)_3$ and the positive aluminum hydroxide formed produce neutralization of the negative charge on the color colloid. Hence there is in the case of negative color a flocculation from these causes as well as the mechanical action of the hydroxide. The underlying theory of these reactions is explained in detail in the footnote on page 91. It is a theoretical consideration and has not as yet been entirely substantiated by experiment.

If color is colloidal in nature, it should be concentrated upon boiling and evaporation of some of the water. This the writer has found to be true, an increase in color proportional to the concentration by evaporation being obtained, and also an increase in opaqueness of the liquid when viewed in the Tyndall ray.

(3) If the color be colloidal, then it should be electrically charged and move in an electric field. If a current be passed through the liquid, there should be a concentration of color at the electrode of opposite sign to the charge borne by the color suspensoid. With

continued application of current, the color in the vicinity of the electrode of the same sign as the charge on the color particles should be reduced to zero. Finally, the discharge of color particles should occur at the electrode of opposite sign, with consequent flocculation and reduction of color there also. The experiments of the writer have been conducted to investigate this phenomenon, and the results seem to entirely justify the conclusion that color in water must be chiefly colloidal in nature, and that it does obey the laws of cataphoresis as outlined immediately above.

Apparatus.

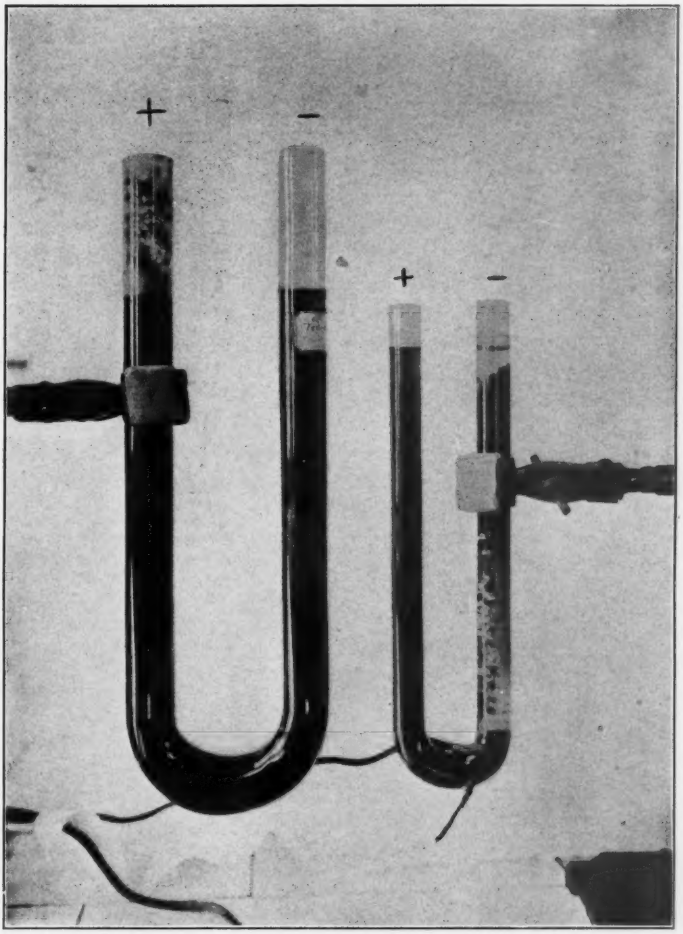
The apparatus used was simple, consisting at first of glass U-tubes varying in size from $\frac{1}{2}$ in. in diameter with 6-in. arms, to 1 in. diameter with 8-in. arms. These were filled with the liquid to be investigated. Electrodes of platinum wire were used, immersed directly in the liquid and connected to a 110-volt d. c. current. The amperage obtained was usually in the vicinity of one milliampere.

Later a somewhat more elaborate tube has been used, fitted with a stopcock at the bottom, so that, when samples were being extracted, each side of the tube could be cut off and prevent any mixing of the liquid. It was found that in the simpler tubes there was a likelihood, especially when there was a precipitate, of causing a disturbance and mixing in the two arms when withdrawing a sample. The arrangement of wiring and general appearance of the apparatus is indicated by Plate II.

Description of Experiments.

1. on tea.

The investigation was begun during the winter, when highly colored waters were difficult to obtain in the vicinity. Earlier experimenters, Hollis, Brown, and Whipple, had all utilized leaf extracts in studies of color. In view of the fact that Hazen and others (2) so persistently advocated the similarity between the nature of color in tea and in water, the writer began his experiments with tea extracts.



Tube at left shows tea extract after being subjected to cataphoresis for 300 hours. Tube at right shows tea extract after cataphoresis with copper electrodes.

At once the phenomenon of cataphoresis was evidenced. There was almost constantly throughout the experiment a decided difference in color between the two limbs of the U-tube, showing the particles to be moving toward one electrode and away from the other. To obey the laws of cataphoresis in their entirety, there should have been a continual decrease in color on one side, and a continual increase in the other side. That this is far from being the case is shown by Table 1. Here it is seen that for the first forty-two hours there was a sudden rise in color in both arms of the tube, the positive arm continuing to rise for sixty-eight hours and then dropping somewhat more slowly than the negative arm. Both arms, however, continue to lose color with time, the positive arm remaining slightly more highly colored than the negative.

In Plate II, to the left, is shown a tube with tea extract after three hundred hours' run. The difference in color is noticeable, that in the positive arm being greater. There is also a heavy froth on top of the liquid in the positive arm, and in consequence there has been a holding back of the oxygen gas which is liberated at this electrode and a pressure developed which is manifest by the slightly greater height of the liquid in the negative arm.

The explanation of the sequence of events in this experiment is not entirely clear, but the writer interprets them as follows: The increase in color at first is due to oxidation of iron or some other element in the liquid, brought about by the oxygen at the positive pole. Some other electrochemical effects are doubtless active. The increase in color ceases when the chemical action producing it has been completed, and the cataphoresis, which has been masked, is now evident. The passage of particles toward the positive electrode is seen, and hence the colloid particles carry a negative charge. Discharge, flocculation, and precipitation at the positive pole occur, with reduction in color. Color reduction is greatest in the negative arm, from which the particles move, and least in the positive arm, toward which they migrate.

The increase in the suspensoid phase in the positive arm increases the viscosity of the liquid, and consequently the oxygen gas escapes less readily and a froth forms. The formation of froth is characteristic of many cataphoresis experiments in water and indicates ordinarily the side to which the color moves. Large

TABLE 1.

Experiments on Tea Extracts.

Experiment No. 1.					Experiment No. 2.			Blank.	
Large Tube. Platinum Strip.			Small Tube. Platinum Wire.		Large Tube. Platinum Wire.				
Hours.	Color, p.p.m.		Color, p.p.m.		Hours.	Color, p.p.m.		Hours.	Color, p.p.m.
	+Arm.	−Arm.	+Arm.	−Arm.		+Arm.	−Arm.		
0	2 750	2 750	2 750	2 750	0	4 300	4 300	0	2 750
3	2 900	3 400	....	....	6	5 200	5 100	42	3 200
22	4 200	5 000	....	....	11	5 500	5 000	261	6 000
42	5 700	3 300	5 200	5 200	20	6 700	6 000	384	7 100
68	5 800	2 300	5 500	1 000	28	7 000	5 500	504	7 100
76	6 000	2 300	5 500	1 000	34	8 600	3 800	648	9 600
93	6 200	2 400	5 100	800	48	8 000	3 500	...	....
125	5 500	2 800	3 300	3 300	56	11 000	3 500	...	....
149	5 500	3 700	2 700	300	63	9 600	3 200	...	....
214	3 700	3 300	1 200	200	72	10 000	2 700	...	....
261	3 600	3 100	300	50	80	10 000	2 400	...	....
288	3 400	3 400?	....	....	88	11 000	2 800	...	....
384	3 300	3 100	180	....	96	7 300	2 500	...	....
504	....	....	....	....	107	10 000	2 300	...	....
648	....	....	....	....	118	9 000	1 800	....	....
...	....	....	....	....	170	6 900	1 600	...	....

masses of flocculated material accumulated at the bottom of the positive arm, showing the color to be charged negatively.

In Plate II, on the right, is shown a tube with tea extract, which was subjected to cataphoresis with copper electrodes instead of platinum. Here there was a very rapid coagulation, the color decreasing from 4 600 to 250 in twenty-four hours. The copper goes into solution, forming an electrolyte, and the color is drawn to and deposited upon the anode.

A number of samples of tea extract were kept under differing conditions for observation as to changes of color. Very evidently there is a slow oxidation going on, as the color in the blank sample rises continuously. The results are tabulated below.

Time.	Unstoppered.	Stoppered.	Stoppered and Sterile.	Unstoppered and Sterile.	Sterile and in Dark.
1 day	3 000	3 000	3 500	3 600	3 300
3 days	3 300	3 200	3 300	3 400	3 400
5 days	4 500	4 400	4 400	5 500	3 700
8 days	7 600	5 200	5 600	....	5 200
2.5 mos.	....	10 000	13 000	....	13 200
3 mos.	....	11 000	29 600	....	15 200
8 mos.	....	8 000	6 900	....	8 000

These show a progressive increase in color for three months, an increase greatest in the stoppered, unsterilized sample and least in the unstoppered, unsterilized bottle. That light plays little part is shown by the fact that the sample enclosed in a dark case has increased in color quite as much as the other samples.

A good deal of time was spent on these experiments, as it was supposed the behavior of water would be somewhat analogous. This was not found to be so, and the undesirability of drawing conclusions relating to color removal from anything but samples of natural colored water is evident. The preliminary experiments on tea did serve to indicate the general behavior of colloidal color in water and to familiarize the experimenter with the technique of his operations. Except for this, these experiments did not aid in the solution of the general problem.

2. ON WATER.

Experiments were made on twelve waters obtained from widely varying sources and localities. In every case, unless specified, all that was done was to send a current of electricity through the water in a U-tube, using platinum electrodes and 110 volts d. c. The color readings were taken at intervals on samples from each arm, and the results are given in Table 2. The discussion of only a few of the waters in detail will be attempted here, as Table 2 presents sufficiently detailed data upon which to base conclusions.

The water from Bridgewater was obtained from a morass in which large trees are growing and which has little or no drainage. The water was obtained soon after the spring rains. It contained a very high iron content, and was distinctly alkaline. There was a heavy brown precipitate in the bottom of the tube. The blank sample upon standing gradually acquired a heavy precipitate in the bottom and the color was reduced. When the color reached this state (oxidation of the iron and formation of the iron hydroxide — a gel*) 18 per cent. was removed by filtration through filter paper. There is no reduction of color when the original water is filtered, the change being due apparently to a change in the state of the iron content. The complex iron colloid is presumably oxidized to the hydroxide, which is insoluble.

The water from Mt. Auburn swamp was somewhat similar to the preceding, but its color was apparently almost entirely due to iron. Upon standing, precipitation took place after flocculation of the iron, and complete decolorization from an original color of 450 resulted in less than two months. This water, however, when fresh, was acid, and the color, therefore, carried a positive charge. For this very reason, the obedience to the laws of electrolysis as well as to those of cataphoresis was marked. The water has been especially mentioned on that account. This was the only water obtained which was acid, and was probably rather unusual for that reason.

In both the experiments noted above, there appears to be a

* Graham distinguished between the two conditions of colloidal solutions as follows: The term "sol" was applied to the liquid state, while to the solid, jellylike form he applied the term "gel." If one of the two components was water, the two corresponding colloidal forms were a hydrosol and a hydrogel (10). These terms are now in common use.

TABLE 2.

Experiments of Water.

Hours.	0		15		20		25		35		40		50		65		90		150		200		Charge.		Acidity.	Alkalinity.	Iron.
Locality.	Color of Water, p.p.m., in +Arm and −Arm.																										
	+	−	+	−	+	−	+	−	+	−	+	−	+	−	+	−	+	−	+	−	+	−	+	−	p.p.m.	p.p.m.	p.p.m.
Arlington Reservoir	55						58	62			48	59											+		..	9	..
Artificial Pond	42										25	20												−	..	..	..
Bridgewater	1 020		580	230											340	230			230	220	160	150		−	..	12	17
Brockton	76						60	76			60	75											+		..	..	23
Charles River	70																		36	24				−	..	..	..
Hopkinton Reservoir	76						45	30					65	5										−	..	..	..
Lost Pond	304										272	248							45	55	30	35		−	..	..	..
Lost Pond	360		280	140											260	236									..	..	..
Marlboro, Crane Swamp	245				240	210							350	160			470	40			450	0		−	..	2	0.75
Mt. Auburn	450										0	88							0	50			+		28	..	9
Mt. Auburn	232												8	25											..	..	..
Washington	110										28	48					33	49	40	15			+		..	..	..
Washington	96						20	96																	..	..	..
Ogeechee River	...						88	40	80	40							26	36						−	..	..	..

double movement, in the nature of a circulation, in each arm of the tube. The nature of this movement in the case of the Mt. Auburn water is shown in Fig. 1.* It will be noted that there are two positions of the top of the flocculated area, numbered 1 and

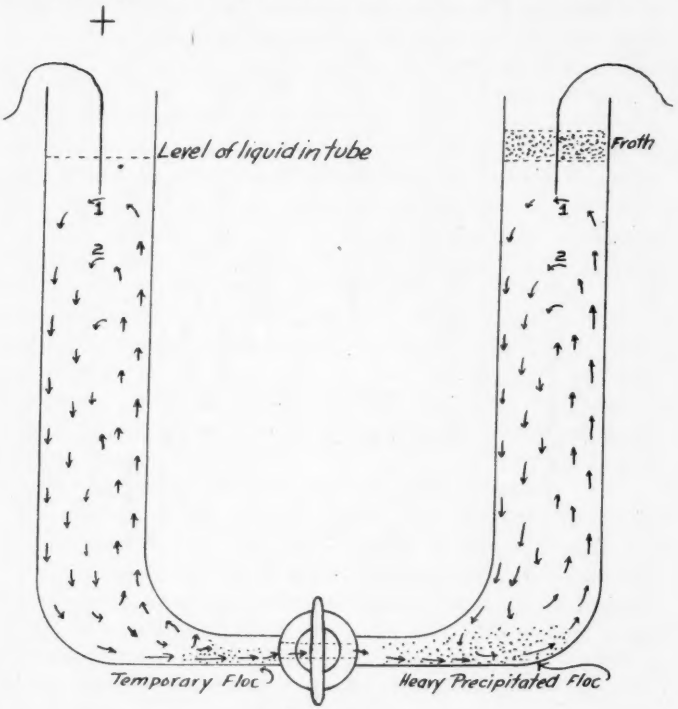


FIG. 1.

Diagram showing movement of positively charged colloid particles when subjected to cataphoresis.

2. At first, the flocculent particles appear to go nearly to the electrodes, but very soon there appears a zone of decolorized water around each electrode, and further movement takes place in the space below this zone. It is presumed that the intensity of the

* This figure shows also the colloid movements when an acid is added to a colored water.

electric field in this zone is strong enough to discharge the colloid particles when they approach its border, and so they flocculate and precipitate before reaching the electrodes. In this particular case all the colloid color particles should theoretically have moved from the positive to the negative electrode. Practically, the constriction in the tube was sufficient to hinder free passage, and certain particles being retained at the bottom took on, probably from contact, a negative charge and were drawn toward the positive electrode, where they were discharged. An alternating charging and discharging of particles in this way is the means which the writer has adopted to explain the frequent formation of floc in both arms of the tube, a phenomenon which occurs in many waters. With time, however, a complete neutralization of all charge on the floc was obtained, and precipitation resulted with reduction in color. The froth appeared only upon the negative arm (in the case cited above where the color is positive), and there was finally a gradual movement from the positive arm to the negative arm of the floc which accumulated in the bottom. All the precipitated particles which cause color will, if the process be carried far enough, be found in the bottom of the negative arm if the color is positive, and vice versa. (Fig. 1.)

If, now, an acid, such as concentrated HCl, be added even in minute amounts to an alkaline water such as that from Bridgewater or Marlboro, the hydrogen ion of the acid, being positive, reverses the charge on the colloid.* The reaction is very rapid,

* Since water (H_2O) dissociates into H+ and OH− ions, it is probable that among other charges carried by the color colloids in water is a positive charge due to the H+ ion of hydrogen. This ion may be in equilibrium with the H+ ion in the water in such fashion that

$$\frac{\text{H+ ion on colloid}}{\text{H+ ion in solution}} = \text{a constant}$$

and similarly for the OH− ions if the adsorption law holds.

If, now, an acid, such as HCl, be added, which ionizes into H+ and Cl− ions, the concentration of the H+ ions in the water is greatly increased, and to maintain the constant relation indicated above, the H+ ions on the colloids must also be increased. In this manner the colloid attains a stronger positive charge than it originally had. If there was only a negative charge, this will be discharged by addition of the H+ ions to the water, and the colloid will adsorb the positive ion. By so much as it increases its positive charge, its tendency to move toward the negative electrode is also increased. That the colloid takes up an H+ ion rather than a Cl− ion is due to selective adsorption.

Similarly, when a base is added to the water, the colloid may absorb the OH− ions (from, say, potassium hydroxide [KOH] which dissociates into K+ and OH− ions), so that its negative charge is increased and it moves toward the positive electrode.

and the electric field set up so strong that a floc appears at once in both arms and moves toward the negative electrode, on which is deposited a brown, jellylike substance. In twenty-four hours the color of the Bridgewater water after addition of 0.025 per cent. $\frac{N}{1}$HCl was reduced from 840 to 0 in the positive arm and to 50 in the negative arm.

If, instead of an acid, the same amount of $\frac{N}{1}$KOH be added to the water, exactly the opposite reaction takes place, with slightly less rapidity. There is here movement in the same direction as the normal water exhibits in this particular case. The rule is general, however, that, irrespective of the original charge on the color particles in the water, the color will move toward and flocculate in the negative arm of the tube when an acid is added; and a reversal of this phenomenon will take place if a base be added. This is in exact accordance with Hardy's law regarding (7) the direction of movement of a hydrosol in an acid or alkaline fluid; namely, that "an immeasurable amount of free alkali causes the proteid particles to move against the stream, while in the presence of an equally minute amount of free acid, the particles move with the stream. In the one case, therefore, the particles are electro-negative and in the other are electro-positive."

What happens here is presumably that in the case where particles in the water are similarly charged to the acid or alkali which

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In the same way, when $Al_2(SO_4)_3$ (filter alum) is added to water, it dissociates into Al+++ and 3 SO_4 − − ions. The color colloid by selection apparently tends to adsorb the Al+ ions. If the color colloid be negatively charged, then the positively charged Al ion serves to cause discharge, and there results flocculation and reduction of color through precipitation of the colloids. Moreover, there is formed hydrous aluminum oxide (aluminum hydroxide), which is a positively charged colloid. This also serves to neutralize the negative charge on the color colloid.

When the color colloid is positively charged, it will not be discharged by addition of alum, and decolorization will not be obtained by the means suggested above. When, however, $Al_2(SO_4)_3$ is added to water, aluminum hydroxide $Al(OH)_3$ is formed, which produces a heavy flocculant precipitate. This, settling more or less rapidly as a matte, gathers up the colloid particles by adsorption and enmeshing, and hence under the influence of gravity the color is carried down with the precipitate, and reduction in color is obtained.

In waters negatively charged, both processes would seem to be effective in color removal; discharge of the negative colloid by the Al+ ion and the hydroxide colloid, and the mechanical removal effected by the aluminum hydroxide. Under these conditions, color removal by alum is probably most rapid and effective. When the color colloid is positively charged, only the mechanical action of the hydroxide can be depended upon, and a larger amount of alum with possible overdosing is consequent.

is added, these particles merely have their charge intensified and the reaction takes place in the normal direction with greater rapidity. In case the particles are of opposite charge to the acid or base that is added, the ionizing effect of the acid or base is sufficient to discharge the charge on the particles and then to charge them oppositely to the original charge. Or the difference in potential may become sufficient and the flow of current strong enough to attract the color particles to the electrode of the same electric sign as themselves. If the difference in potential be great enough, positively charged particles may be attracted to the positive electrode, and thus the phenomena described may also be explained, on this hypothesis.

In most of the waters investigated there was a reduction of color in both arms of the tube upon cataphoresis. The reduction in the arm carrying the electrode of opposite charge to that on the particles was always less than in the other arm, and the froth always appeared on the arm toward which the colloid color particles moved. An explanation of the occurrence of froth has already been advanced. The cause for the reduction in color in both tubes is explained by two processes.

There is free oxygen given off at the positive electrode, and here the color particles (especially if they be negatively charged and so concentrated at that electrode) may be oxidized so as to lose their color. The most important cause, however, is supposed to be due to precipitation of the color colloids. There will be a reduction in color in the arm carrying the electrode of similar sign to the color colloids from migration of the colloids to the oppositely charged electrode. The slight reduction in color in the arm carrying the electrode of opposite sign to the colloids is due, as stated, to discharge in the vicinity of the electrode in this arm, and subsequent flocculation and precipitation. The flocculent particles are frequently not visible to the eye, but the reduction in color is usually evident, and after a time the accumulation of the precipitate in the bottom of the tube is conspicuous.

If all waters behaved in this fashion, with a reduction of color in both arms of the tube, the response of color in water to cataphoresis might not be considered entirely conclusive. Fortunately, two waters were found in which the color obeyed almost exactly

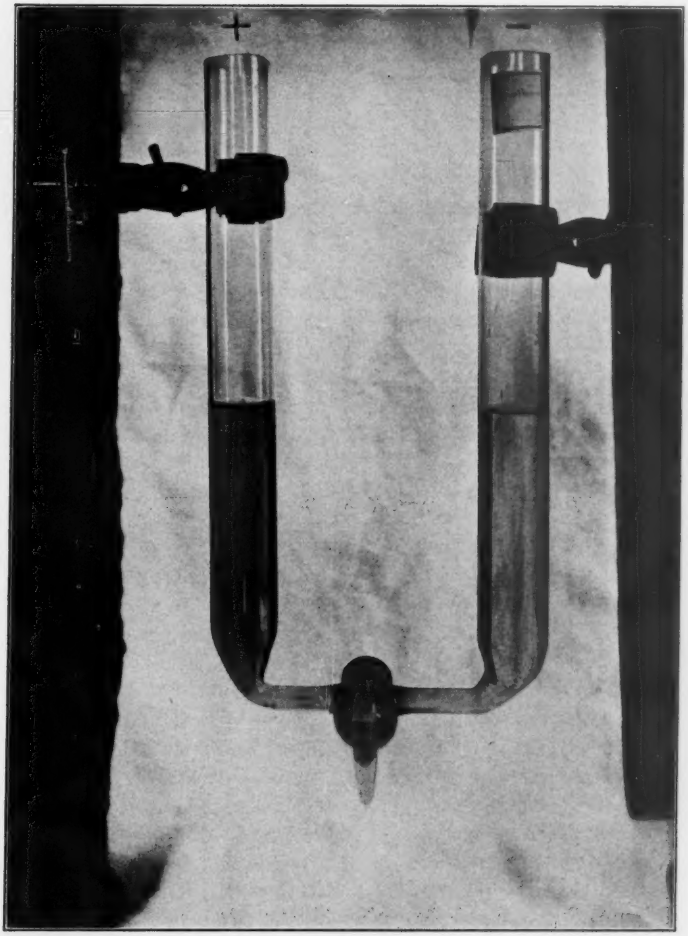
the theoretical laws of cataphoresis in colloid solutions. The Marlboro water is seen from Table 2 to have had an original color of 245. At the end of fifty hours the color in the positive arm had risen to 350, while that in the negative arm had decreased to 160, a mean of 255. After ninety hours, the colors in the positive and negative arms were 470 and 40 respectively, a mean of 255 again. After two hundred fifty hours, the colors were 450 and 0, a mean of 225, showing that the reaction was complete and precipitation had begun. The difference in color of the two arms of the tube is well illustrated by Plate III, taken at the end of two hundred fifty hours. The flocculated particles in the negative arm in the photograph are simply those few which the constriction in the tube prevents from passing to the positive arm.

It should be noted that not only is there a constant increase in color in the positive arm and corresponding decrease in the negative arm, but that the mean of the color in both arms is almost constantly very nearly that of the original water (245), as should theoretically be the case if there were no precipitation. If the current be kept on, precipitation will occur, a floc forming in the positive arm. There is doubtless some earlier flocculation not apparent to the eye, and this accounts for the decrease observed in the color of the mean after two hundred fifty hours.

That this water follows so closely the laws of cataphoresis is doubtless due to the fact that both alkalinity and iron content are almost negligible, a condition not found in the other waters examined. There were, therefore, no electrochemical reactions upon the complex iron colloids which interfered with the cataphoresis of the color colloids.

The waters from Hopkinton Reservoir and the Ogeechee River exhibited similar properties, an increase of color in the positive arm and a decrease in the negative arm. As the first of these waters is from Massachusetts and the second from Georgia, the colloidal condition of color in water was not of local occurrence. The color in these waters, however, was somewhat less stable than that in the Marlboro water, and the reduction in color in both arms soon appears with flocculation and precipitation.

The water from Lost Pond in Brookline is interesting because of the apparent change in character of the charge carried by the



Appearance of U-tube containing Marlboro water after being subjected to cataphoresis for 250 hours. Color in positive arm is 450, and 0 in the negative arm.

colloid color particles. The color is originally negatively charged, but after one hundred hours there has been a great reduction in color from neutralization and precipitation of the color colloids. It will be seen that at this point there is apparently a reversal of charge on the colloids remaining in suspension, and a consequent migration to and increase of the color in the negative arm. This reversal of color is explained in two ways. First, the normal negatively charged colloids have migrated to the positive electrode. Here most of them have been discharged and precipitated, but some have taken on a positive charge from this electrode and so move back toward the negative arm. In the second place, what little iron is present has become oxidized to the ferric state and become a positive colloid. Hence it tends to move toward the negative arm.

The water from Lost Pond showing these characteristics was obtained in the spring of 1916. Some water from the same place has been obtained this fall and does not show the variations noted above. This would indicate a more stable color and seem to show that the condition of the color in water varies at different seasons of the year.

In connection with the investigations outlined above, showing the colloidal nature of coloring matter in water, mention should be made of certain experiments made by Mr. M. C. Whipple in the Laboratory of Hygiene and Sanitation at Harvard University in 1913. These experiments consisted of placing in flasks leaf extracts and natural waters having colors ranging from 100 to 150. Over the tops of the flasks, sheepskin parchment was tied and the edges paraffined to make watertight. The flasks were then inverted with the lower ends submerged in beakers of distilled water. In no case did the color of the distilled water increase appreciably, although there was change in alkalinity content, showing that dialysis took place. The color, therefore, apparently existed in the condition of particles too coarse to pass through the parchment, for if the color had been due to substances in solution, it would have passed through by dialysis. Moreover, illumination under the Tyndall ray showed the presence of a large amount of colloidal substances in the colored extract, but none in the distilled water even after three hours. The colloidal

nature of coloring matter in leaf extracts, and in natural waters, is thus substantiated mechanically by these experiments, as well as indicated electrically by the investigations of the writer.

Change in Color with Storage.

Various waters were subjected to storage under varying conditions, the bottles being kept in the ordinary light of the laboratory.

The reduction of color by storage under room conditions was little unless the water contained a high iron content, which was easily brought into the ferric state and precipitated, as was the case with the Mt. Auburn water, and that from Bridgewater. In this event, the ferric hydroxide formed was a hydrosol and, upon contact or oxidation or by other means, was changed to the gel state and became a colloidal floc, when precipitation and reduction in color occurred.

In the open air, exposed to sunlight, there is always reduction of color in greater or less degree. The so-called bleaching action so frequently observed in the upper portions of reservoirs is possibly due in large measure to the action of the sunlight in breaking up the complex iron color colloid into some state in which its iron content may be oxidized and precipitated as described heretofore. The influence of sunlight upon waters of different degrees and state of color is well illustrated in the last three waters of Table 3. The Mt. Auburn water having an iron content of 9 p.p.m., which was readily brought into the hydroxide state even under room conditions, was completely decolorized upon standing in the open air. The Lost Pond water, having an iron content of 2 p.p.m. and color colloids of iron which were less readily brought into flocculation, was decolorized 66 per cent. in the open air. The Marlboro water, with very low iron content, 0.75 p.p.m., and color due largely to other than the iron colloids, shows practically no reduction of color upon exposure to light. This would indicate that bleaching action *per se* by sunlight was in no large degree responsible for color reduction, but operated only so far as it produced chemical changes affecting the stability of the complex color colloids.

The growths of algæ were pronounced in the Lost Pond water when exposed to sunlight, and did not occur under laboratory

TABLE 3.

Locality.	Condition.	Original Color.	Storage, Days.	Final Color.	Per Cent. Reduction.
1. Lost Pond	Filtered, not sterile.	360	58	360	0
2. Lost Pond	Filtered, not sterile.	360	58	360	0
3. Lost Pond	Filtered, not sterile.	360	58	380	−5.5?
4. Lost Pond	Incubated in dark at 37 degrees.	360	58	340	5.5
5. Mt. Auburn Swamp	Natural condition.	450	60	0	100
6. Bridgewater Swamp	Normal condition.	1 020	58	690	32
7. Mt. Auburn	Exposed outside window sill.	450	35	0	100
8. Lost Pond	Exposed outside window sill.	360	35	120	66
9. Marlboro	Exposed outside window sill.	245	35	240	2?

conditions. It is probable that these growths influence color removal, color colloids being retained on the gelatinous slime formed by them and so carried to the bottom.

Conclusions.

As a result of the experiments outlined above, the writer presents the following theory of the colloidal nature of coloring matter in water. The writer believes that the colloidal theory offers an explanation of many of the obscure and contradictory behaviors of colored waters toward coagulating agents and toward the general processes of decolorization. The theory that coloring matter in water is in part at least colloidal in nature is not new, but the investigations and elaboration of this theory presented herewith are believed to represent more advanced data upon the subject than have heretofore appeared.

Color in water in large part exists in the form of colloidal suspensions of ultramicroscopic particles or "suspensoids." Some of the color may be due to colloidal emulsoids. A small part of the color is probably due to non-colloidal material, organic acids, and neutral salts in true solution. The colloidal coloring matter, whether suspensoids or emulsoids, carries an electrostatic charge. This charge may be positive or negative, depending on the character and source of the water, and varying in different waters. Color in water is usually due to negatively charged colloidal material.

These charged particles are of such minute dimensions that, if allowed to remain quiescent under the influence of gravity alone, they would remain suspended for very long times. Being similarly charged, they tend to mutually repel each other and remain in suspension indefinitely, a tendency which is strengthened by convectional temperature currents, wind, etc.

Since these particles carry an electric charge, and are in colloidal suspension, they obey the laws of cataphoresis when an electric current is sent through a colored water. The particles are attracted to the electrode of opposite sign from the charge which they carry. There they are discharged, flocculate, and precipitate, with consequent reduction in color of the water. This type of reaction may be, and often is, modified by electrochemical

reactions, the reaction being theoretical only in those waters having little alkalinity or iron content.

When an acid is added to a colored water, the color migrates to the negative electrode. When a base is added, the color goes to the positive electrode. This is in accordance with the laws of Hardy outlined above.

Decolorization by Sand Filters.

Sand filtration has been found inadequate for the removal of color from highly colored waters. The degree of removal is very variable, depending on the water and the nature of the sand. A pure quartz sand (11) will remove little color, while sands containing much iron, aluminum, or manganese remove a large proportion of color. It is evident that the presence of iron and allied elements in a sand has an important effect upon the capacity of that sand for color removal. In general, experiment has shown that about one third the color in water can be removed by filtration through sand. That more color cannot be removed may be explained on the hypothesis that the colloidal particles of which it is composed are so extremely fine as to pass in large measure through the smallest capillary pores in the sand. It is possible also that the color colloids removed by filtration are of opposite charge to the filtering medium. The color not removed may not have come in contact with the filter material or may carry the same electrical charge.

Decolorization by Flocculation with Electrolytes.

This is perhaps the most general method of clarifying colored or turbid waters. Either alum or ferric hydroxide and lime are commonly used as coagulants. The general principle of these reactions upon the basis of the colloidal theory has been explained at length.* To summarize: It may be said that where most successfully used, the action depends upon the discharge of a negative color colloid by the positively charged ion of the coagulating agent and the positively charged hydroxide which is formed. The consequent neutralization of the charged color colloids results in flocculation, precipitation, and decolorization. This process is

* Footnote, page 91.

materially aided by the mechanical removal of the color colloids by the hydroxide floc which is formed.

When clarification is obtained with difficulty, the reason is frequently that the color colloids in the water bear a positive charge. Hence they are not discharged by the positive ion of the dissociating coagulant. Under such conditions, the removal of color is supposed to be entirely a mechanical process resulting from enmeshment and straining out of the color colloids by the precipitated hydroxide floc.

It is well known that a high alkalinity frequently causes difficulty in color removal. This is explained by the fact that the elements causing alkalinity are negatively charged. If, then, the color also be negatively charged, a correspondingly greater amount of positively charged coagulant ion and hydroxide will be necessary to cause neutralization and precipitation.

By Storage.

Some engineers believe that the removal of color in water consequent upon storage for long periods of time in large reservoirs is due to the bleaching action of sunlight. When decolorization occurs at considerable depths in the absence of light, oxidation has had to be adduced to explain the phenomenon.

That waters do become decolorized by storage is undisputed. It has been shown (1) that bleaching by sunlight is capable of removing color in water, but the writer doubts the competency of this process to explain the considerable color removal in reservoirs. If, as has been suggested in the foregoing statements, the color in water is largely due to particles in a colloidal state, the precipitation of such particles by storage is largely a matter of electrostatics.

The various streams tributary to a reservoir doubtless carry color particles having different charges. There is also more or less sediment in water, which generally is negatively charged. The mixture of all these variously charged particles in the reservoir probably tends to discharge certain of them, with consequent precipitation and decolorization.

Such, however, the writer believes to be only a minor cause of decolorization by storage. It was early shown by Hollis

(13) and later by Whipple (1) that the increase in color with depth in reservoirs is due primarily to the condition of the iron content; that at depths the iron is reduced and taken into solution; that upon rising to the surface in the spring, the iron is oxidized and adds to the color. That stagnation or storage will bring about an increase in color of the lower layers of the water which, given proper conditions of wind and temperature, may effect the upper layers, has also been shown by Whipple (1).

Notwithstanding this, there is in many reservoirs a decided decrease in color. What, then, is the cause of this decolorization, and how may it be explained by the colloidal theory? It seems probable that the iron content is the most important factor in this decolorization. Iron is important in sands for removing color; is a direct precipitant in the case of addition of electrolytes; is the factor upon which color removal by bleaching depends (see Table 3 and page 95); is the direct cause of color at the bottom of reservoirs; *in short, iron is probably the chief element influencing the presence and removal of color in water.* The iron probably does not exist in any such simple condition as the ferrous or ferric state. The iron content in color is supposed to exist in the form of certain organic compounds that are in colloidal state,—chemical compounds of extreme complexity. Due to many processes, of which oxidation and electrostatic neutralization by other colloids are the most active, iron is brought into the ferric state, in which case it exists as a hydrosol and will be precipitated by clay or any other negative colloid. Otherwise, some slow chemical change is brought about so that the complex iron suspensoid is broken up into constituent particles which may carry opposite charges and so mutually precipitate each other, or which may be discharged by other differently charged colloids present in the water.

In general, it may be said that most coloring matter in water, whether due to iron or not, is charged; and that the color suspensoids mutually repel each other, tending to maintain their suspensoid phase. In large bodies of water, however, agitation by convectional and wind currents, oxidation, algæ growths, etc., all tend to bring about contact between the color suspensoids and other colloidal substances in the water, many of which bear an opposite charge. There will tend to be discharge and neutrali-

zation. The particles will then flocculate and precipitate, and reduction of color will be apparent.

It has long been noted that, when certain turbid streams in the West carrying clay in suspension come into confluence with highly colored but clear rivers, there is sometimes a reduction in both color and turbidity in the effluent stream. This is readily explained on the hypothesis advanced above if the color and turbidity bear opposite charges. In the same way, prospectors in the West state that muddy turbid pools of water can be cleared well enough to drink from merely by moving about in them a piece of cactus stalk. This phenomenon, too, is explained by the colloidal theory, since the cactus sap is acid and hence carries a strong positive charge. The negatively charged clay is thus neutralized and precipitated.

The writer believes, therefore, that not only is color largely due to charged colloidal particles, but that the state and degree of iron in the water is the controlling factor, both as to the permanence of the color and its ease of removal. The latter is undoubtedly much influenced by the alkalinity, — a high alkalinity making for difficulty in color removal. The alkalinity increases the negative charges and also possibly makes for electrostatic stability of the complex iron suspensoids. The addition of alkali to water in the same way seems to operate to prevent neutralization of the electric charge on the complex iron suspensoid, thus maintaining the suspensoid condition and preventing flocculation and precipitation.

If any one conclusion is evident from these investigations, it is that generalized statements and rules regarding color in water and color removal cannot be made. Every water is in this respect a law unto itself, and the problem of color removal from any given water can be intelligently approached only after detailed study as to the nature and electrical properties of the color in that particular water.

There is great opportunity for further investigation along the lines of colloidal color in water, and that these investigations will undoubtedly prove helpful in the solution of the color removal problem is obvious. Such investigations, however, belong more properly to the water supply chemist than to the engineer. These

problems must be approached with an unbiased attitude, for hitherto preconceived ideas have militated against a fuller understanding of the subject. While it is probable that all color changes and removal in water are not wholly due to the colloidal properties of the coloring material, yet it would seem that the colloidal theory may be looked to for a more complete understanding of the nature of color in water, and for a more satisfactory solution of methods for its removal than now obtain.

ACKNOWLEDGMENT.

The results of the investigation and studies presented in this monograph are the outcome of experiments carried on in the Laboratory of Sanitation and Hygiene at Harvard University. The subject was first suggested to the author by Prof. G. C. Whipple, to whom is due very sincere appreciation for many courtesies extended, for advice and criticism, and for facilities and equipment for experimental work. The writer is also greatly indebted to Mr. M. C. Whipple, instructor in sanitary chemistry at Harvard University, for his constant aid, advice, and helpful suggestions; to Prof. E. B. Millard, of the Massachusetts Institute of Technology, for advice regarding certain details of the chemistry of the problem; and to Mr. George Broussard, for help rendered in the laboratory.

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DISCUSSION.

MR. GEORGE C. WHIPPLE.* I wish to express my appreciation of the careful work which Mr. Saville has done in connection with this investigation. I am glad we are going to have this paper spread upon our records, because it will show to the world that this Association is interested not only in the art of water supply, but in the fundamental science of water purification. It is a good thing once in a while to get a bath of science such as this. As Mr. Saville said, this is really a preliminary contribution to this subject. We have undertaken to solve a specific problem, and that is to find out some way to decolorize water

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without the use of chemicals, or, at least, to decolorize water without the use of such a chemical as alum. At the present time the only way which we know of decolorizing water is by the use of alum. That is the most satisfactory method, as Mr. Weston and as Mr. Johnson and others have already pointed out; and yet we all realize that this method has its shortcomings, and if we can decolorize water without the use of chemicals, or in some better way than at present, we shall accomplish something which is practical and worth while for the people of New England, where this condition is especially important. Therefore, I would regard this as a preliminary contribution. We hope that the results of other investigations now under way will be presented to you later.

Mr. George A. Johnson.* *Mr. President and Gentlemen,* — I have been highly instructed by Mr. Saville's paper and feel that there is very little I can contribute at this time. I am, however, somewhat curious to know about in what direction these studies may be practically applied to the decolorization of water on a large scale. Professor Whipple has expressed the hope that these studies may ultimately result in revolutionizing the existing methods of water decolorization, particularly with reference to the abandonment of the present methods. It would be very interesting to me if an indication could be given to-day as to how these new methods could be applied in practice, and about how their cost with equal efficiency would compare with the methods now in use. I am sure I shall look with a great deal of interest and anticipation for the results of future experimentation along these lines.

Mr. Francis F. Longley.† All of those present who are interested in problems of color in water, and in this part of the country most of us are so interested, will feel under obligation to the author of this paper for his clear presentation of the results of these experiments.

It is about fifteen years since the classic discussion before the American Society of Civil Engineers on the decolorization of water, led by Professor Whipple. Aside from the bare recognition of the existence of color in so great a proportion of our sur-

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face supplies, the subject a short time before that discussion was a new one. The weak-tea color in our water supplies was taken as a matter of course. That discussion, however, was characterized by the unusual fullness with which the subject was treated. The facts there stated and the records of experiments there set forth have been quoted up to the present time, with little if any modification, as the best data available upon the subject of color in water.

Since then, the nature of coloring matter has not changed. The methods of observation of color so well thought out and established at that time are still the same. Our knowledge regarding its origin has increased, you might say, in volume, but not in weight, and our knowledge regarding its chemical construction as determined by the ordinary procedures of chemistry, organic or inorganic, has not made any measurable strides.

Our present conception of color in water was not touched upon in that discussion. Due mainly to the teachings and developments of physical chemistry, we to-day think of coloring matter in water in slightly different terms, and the studies described in the paper under discussion are of particular interest in this connection. We now look upon color, so to speak, with ultramicroscopic eyes. Instead of a true solution of organic matter, we see, for the most part, a suspension of ultramicroscopic particles; in other words, a colloidal suspension. We see the influence of gravity upon these particles offset by other forces, which may hold them indefinitely in suspension. And, as far as our studies go along these new lines of thought, we see these particles conforming in general, if not in every particular, to the physical and electrical laws of colloidal suspensions.

This is bound to stimulate new lines of thought for the treatment of water for the removal of color. We can hardly say we have progressed very far in that direction as yet, but our manner of thought towards this problem is changing, and we are beginning to give consideration to physical and electrical characteristics of the coloring matter to which no attention was paid a few years ago.

In the old paper above mentioned, the removal of the color from water by natural agencies and by chemical means was dis-

cussed. Professor Whipple and Mr. FitzGerald, referring to work done by the Boston Water Board, described what had been done to determine the laws governing the reduction of color by sunlight, which was recognized as one of the most potent natural agencies in decolorization.

In the paper under discussion, the author makes the statement that " bleaching action, *per se*, by sunlight, was in no large degree responsible for color reduction, but only inasmuch as it produced chemical changes affecting the stability of the complex color colloids." It has always been recognized that the oxidation of iron aided materially in the natural removal of color. Whipple and FitzGerald both touched upon this. It seems to me it would be a mistake, however, to leave the impression that the oxidation of iron alone was responsible for the decolorization of reservoir waters.

Dr. Soper, in the discussion of fifteen years ago, emphasized the view that oxidation is the step by which color disappears in any process; that when carried to its furthest point, oxidation must destroy all coloring matter of organic origin. Extending his discussion of this view, he continued that atmospheric oxygen is too stable and inert to unite readily with organic matter, and hence aëration of water is of little direct use for the removal of color, but that ozone, which is a highly active oxygen, if brought into contact with water containing color, destroys and mineralizes it.

All this is possibly true. But why do we need to feel that stored water loses its color only by the *destruction* of the organic matter? Looking again through our ultramicroscopical eyes, it is reasonable to suppose that any action which will destroy the electrostatic or other obscure physical properties of these minute particles of color material in such a way as to permit the force of gravity to become effective upon them, and especially if this action increases the size of the particles, as by flocculation, will result in the removal of color by simple sedimentation.

There is no lack of possible agencies that might help in this action. Foremost amongst these is oxidation, and in this, iron plays an important part. There is the mixing of colored waters from different sources, and with possibly different electrical charges,

the mixing of colored waters with the stored waters in which action of this sort has already advanced, and the addition of ground water. There is the growth of algæ, with the accompanying formation of oxygen. There is the action of bacteria, which are at times thought to produce a fermentation of the organic matter.

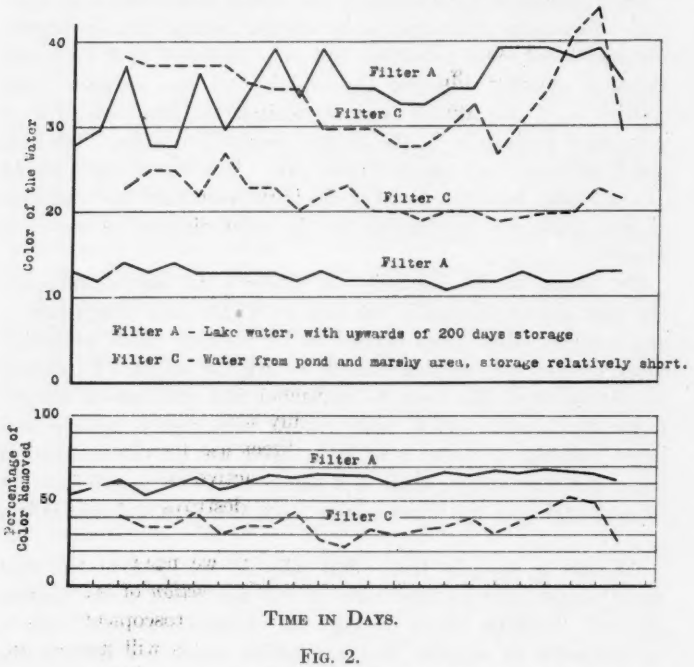

Fig. 2.

Color removal by sand filters from two waters of different periods of storage.

There is adsorption. And there is sunlight, with its well-known powerful actinic effects.

One could perhaps speculate much further as to possible factors in this. We do not yet know enough about any of these to conclude categorically that this factor does and that factor does not affect the final results, and in what degree.

Whatever the steps in the process, which are so obscure that

there seems but small hope of ever defining them and measuring their effects, it appears from the available evidence that a part, at least, of the colloidal suspension that produces the effect of color in water increases in effective hydraulic value and probably in size under the influence of the various natural agencies, and in the course of time finds its way to the bottom of the reservoir.

In this final result, the writer believes his views do not differ materially from those of the author of this paper.

Some results obtained from two small sand filters in a recent investigation lend strength to the view that the ultramicroscopical particles in a stored water are larger than those in a similar water of about the same color, but which has not had the benefit of much storage. These results are shown on the accompanying diagram (Fig. 2).

These two slow sand filters were identical in design. They were operated at the same rate, namely, 5 mil. gal. per acre per day. They were operated on the same drainage area, at the same time, and on waters having substantially the same initial color. All conditions were practically identical for the two filters, except the length of time the water stood in storage. Water applied to Filter A was taken from a lake of about 250 acres area, with a draft of about 6 mil. gal. per day. The period of detention was upwards of two hundred days. Water applied to Filter C was taken from a small pond and marshy area. The period of detention was not known, but it was irregular and relatively short.

The percentage removal of color from the stored lake water was nearly twice as great as from the other. This was due to some important difference in the physical condition of the particles of the colloidal suspension, and the most obvious inference is that they were larger in the stored water.

Perhaps the commonest method of distinguishing a colloidal from a crystalloidal form of matter is to determine its rate of dialysis through a suitable membrane. Various membranes may be used for this, the best probably being goldbeater's skin. Membranes of sheepskin and of collodion are sometimes used, but the commonest and most convenient membrane is parchment paper. It cannot be said that matter in the colloidal state will not pass through such a dialysing membrane in any degree, but

it is true that true crystalloids in solution pass through readily, and that the rate of passage of the colloid is so very slow as to make this an interesting means of classification. The author makes reference in his paper to some experiments made along this line by M. C. Whipple, and the writer has record of other experiments of this kind that he thinks interesting enough to present.

Some samples of water, colored with various substances, were put through a dialysis test with the results shown on the accom-

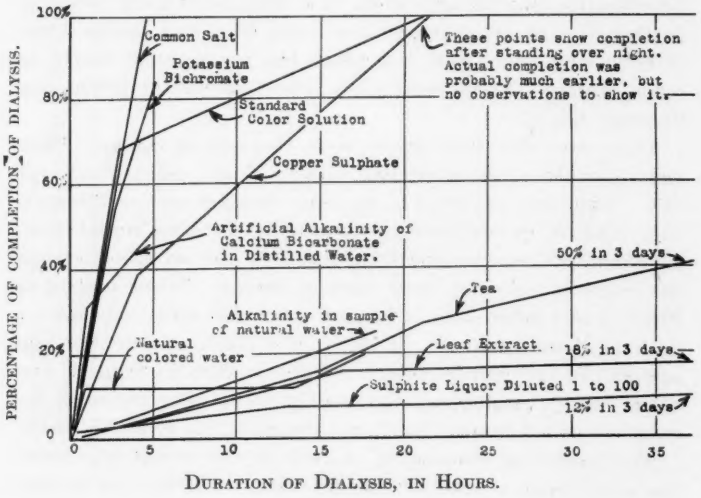

FIG. 3.

Diagram showing difference in rate of dialysis of various coloring substances.

panying diagram (Fig. 3). The true crystalloids such as sodium chloride, potassium bichromate, copper sulphate, and others, passed through completely within a period of a very few hours. The action was rapid from the start.

On the other hand, the coloring matter of natural water, of tea, of leaf extract, and of sulphite liquor passed through only in small degree and very slowly. In twelve hours not more than 15 per cent. of any of these colors had passed through the mem-

brane. In twenty-four hours not more than 30 per cent., and in most cases not more than 20 per cent., had passed through. In three days about 50 per cent. of the coloring matter of tea had passed through, but not more than 20 per cent. of the color of raw water, leaf extract, or sulphite liquor had passed through.

In another experiment of the same kind, some 10 or 12 per cent. of the color passed through in one hour, and only 25 to 40 per cent. had passed through in three days.

Mr. Lounsbury, at Superior, using fish bladders as a dialysing medium, found that the sometimes highly colored water of Superior, which is heavily charged with iron, passed only a small proportion of its color in several weeks, whereas the coloring matter of tea passed through much more rapidly.

There is evidence that the organic matter in water is sometimes intimately combined, not only with dissolved iron, but also with the alkalinity. The amount of alkalinity in the form of calcium carbonate theoretically necessary to combine with 100 lb. per million gallons of aluminum sulphate is about six parts per million. It has been found at times that if a dose of aluminum sulphate be added to a colored water in the quantity computed to use up all the alkalinity on this basis, and to make the water acid, it does not always become acid, but retains a small alkalinity. Observations of this sort have suggested the inference that there is alkalinity present combined in some way with the color so that not all of it responds to the usual indicator, and that the addition of the mineral acid radical of the coagulant results, first, in combination therewith of the proper amount of available alkalinity, and, second, some alteration of the delicate balance of the dilute solution, with more alkalinity splitting off from the weak acid color in a form that the indicator will detect. Instead of the six parts per million that is indicated by the conventional formulæ for the reaction, alkalinity reduction is often found to be five, four, and even as low as three parts per million for each 100 lb. per million gallons of aluminum sulphate. This phenomenon has been noted often, and has sometimes been explained by absorption of some of the aluminum sulphate by the color or the turbidity in the water, or perhaps by incomplete chemical reaction in the presence of low alkalinity. The evidence

as to the exact cause is not convincing, but it is interesting to note the behavior of the alkalinity upon dialysis.

It was inferred that the passage through a dialysing medium of the alkalinity in a naturally colored water would be less rapid than in the case of an artificial bicarbonate alkalinity. This was tried out and found to be true. Artificial alkalinity of about fifty parts per million was made up in distilled water. Upon dialysis, some 30 per cent. passed through in one hour and 50 per cent. in five hours. A colored natural water subjected to dialysis under practically identical conditions passed only 25 per cent. of its alkalinity in eighteen hours, indicating a much slower action. Violent and prolonged boiling seemed to break up, to some extent, the combination between the organic matter and the alkalinity so that 70 per cent. of the alkalinity of a sample of raw water so treated passed the dialyser in seven hours.

The removal of color by means of aluminum sulphate is influenced by the amount of alkalinity in the water. For a given water there is an alkalinity comparatively low and not many points above the neutral point where the coagulation seems to be best.

The difference in behavior of natural color and of the color of true crystalloids, and of natural and artificial alkalinities when subjected to this treatment, is conspicuous, and affords an additional bit of convincing evidence as to the nature of the coloring matter in water.

The use of aluminum sulphate in connection with water filtration is the most common means of artificial removal of color. The author has pointed out that this occurs, in general by the discharge of a negative color colloid by the positive ion of the coagulant, aided by the mechanical removal effected by the hydroxide of the coagulant. As he further indicates, the action may not always occur in this way, and different waters vary a great deal in their response to this treatment.

Some interesting records of the relationship between coagulant required, and the color thereby removed, are presented in a diagram (Fig. 4). As a basis for comparison, there is also given the line used by Professor Whipple fifteen years ago to show the amount of aluminum sulphate required to decolorize waters of

moderate alkalinity, which line has been much used and quoted since then. All of these lines are, of course, average lines, and the originals show the plotted points scattered widely on both

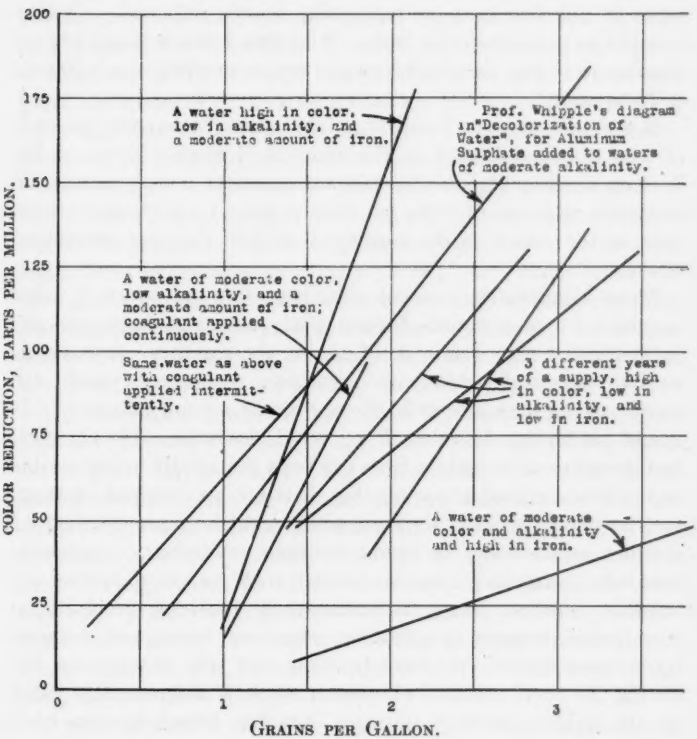
200
175
150
125
100
75
50
25
0
0
1
2
3
COLOR REDUCTION, PARTS PER MILLION.
GRAINS PER GALLON.
A water high in color, low in alkalinity, and a moderate amount of iron.
Prof. Whipple's diagram in "Decolorization of Water", for Aluminum Sulphate added to waters of moderate alkalinity.
A water of moderate color, low alkalinity, and a moderate amount of iron; coagulant applied continuously.
Same water as above with coagulant applied intermittently.
3 different years of a supply, high in color, low in alkalinity, and low in iron.
A water of moderate color and alkalinity and high in iron.

FIG. 4.

Diagram showing quantity of aluminum sulphate required for the removal of color from various waters.

sides. They serve, however, to illustrate the difference in the nature and magnitude of the action upon waters of different characteristics.

The extreme line of this diagram is significant as showing the

resistant nature of a high iron content in this water. The experimenter said of this: "The iron is precipitated with difficulty by ammonia. At times it is found that the iron would all be precipitated with the first addition of ammonia, and at other times it was necessary to repeatedly acidify and make alkaline in order to precipitate the iron. With this water it is not always possible to obtain the sulphocyanide test even when iron is known to be present."

It does not seem to be always true, however, that the presence of iron causes difficulty in the removal of color. Three of the lines on the low side of the diagram represent waters containing moderate amounts of iron, yet they present no particular resistance to the action of the coagulant as does the case mentioned above.

These comparatively recent ideas regarding the nature of color should serve to stimulate further study aimed at improvements in methods for its removal. Can we, for instance, discover effective means of action not heretofore recognized which will enable us to dispense with the use of aluminum sulphate? It would be highly desirable if we could, for while this chemical has served us well, and, in fact, has been practically indispensable in the treatment of many supplies, it is not an unmixed blessing, and in certain respects those supplies might be more satisfactory if other means could be found for their preliminary treatment. And what artificial forces can be used to bring about mutual attraction amongst these ultramicroscopic particles, resulting in flocculation, increase in subsiding value, and consequent removal by sedimentation? We already know well that flocculation following the application of aluminum sulphate is materially aided by the right amount of agitation, and this knowledge has been profitably applied in practice.

Can any of the methods suggested by the interesting laboratory results recorded in the paper be applied successfully on a large scale? Can they be speeded up sufficiently to make them practicable? Can they be accomplished with reasonable economy? Unfortunately, the laws involved are not so simple and so easily understood as the conventional physical and chemical laws that govern the actions as we have understood them in the past, but

nevertheless the field is a large one and an interesting one, and these and other similar questions wait for an answer. As it becomes more clearly recognized that profound actions hinge upon obscure factors such as the concentration of ions of one sign or the other, or the electrostatic charges upon the colloidal particles that produce the color effect in water, and as the advance guard of scientists connected with our public health and water supply questions succeeds in devising means for the convenient measurement and control thereof, we may hope for interesting developments in the direction of the decolorization of water.

MR. ROBERT S. WESTON.* This exceedingly and wonderfully clear-headed paper, which I think we will all read with great care when it is published in the JOURNAL, suggests to our minds great possibilities in the way of color removal. As I have listened to the paper this afternoon I have been impressed with the way that the experimental data accord with our experience. I feel that this is just the beginning of something which will, perhaps, lead us beyond our present not entirely satisfactory methods.

MR. SAVILLE. I wish to say that this matter has been emphasized, both by Professor Whipple and myself, as being in the nature of a progress report. We believe that every bit of experimental evidence that we can get on any scientific subject, and we do believe that color removal is a scientific subject, is of value; and what we have to present just now is, perhaps, more in the nature of suggestions to water-works men. In reading the paper they may be able to apply some of the suggestions there presented to their own work, and then later, if our own experiments show a commercially applicable method, perhaps we shall have something more definite to say.

THE PRESIDENT. I think that some of the members will appreciate Mr. Saville's offer to have us send in for experimental work any highly colored waters we have.

MR. MELVILLE C. WHIPPLE † (*by letter*). The studies in which Mr. Saville has been engaged are particularly interesting and attractive to experimenters in water-works problems. He has applied a unique method to his work, and has described results

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which add materially to our knowledge of the true nature of color in water.

It occurred to the writer that the presence of CO_2 might exercise some effect on the migration of colloidal coloring matter in the electrical system described by Mr. Saville. Accordingly, experiments were made upon waters from widely separated localities, first, by simply passing a current through the U-tube, and, second, by passing a current and also a slow stream of CO_2. The results are given in the table below. These tests were not many in number and were undertaken primarily to suggest further lines of research.

Color readings in parts per million on the platinum scale are given for the water before the experiment and for the water in the positive and the negative arms of the tube after the experiment. It should be borne in mind that coloring matter found in the positive arm carried a negative charge, and that in the negative arm a positive charge. The percentage that the reading in the negative arm was of that in the positive is also given, and it is to these figures that attention is directed. A control experiment was also made by passing a stream of CO_2 through the water for twenty-four hours. A negligible reduction of color resulted.

TABLE SHOWING EFFECT OF PASSING A DIRECT CURRENT THROUGH COLORED WATERS, AND ALSO OF PASSING A CURRENT AND A STREAM OF CO_2.

Source of Sample.	Original Color.	Color without CO_2.			Color with CO_2.		
		Pos. Arm.	Neg. Arm.	% Neg. was of Pos.	Pos. Arm.	Neg. Arm.	% Neg. was of Pos.
Black River, Watertown, N. Y.							
27-hour experiment	70	82	75	91	80	48	60
27-hour experiment	70	72	67	93	68	44	65
Exeter River, N. H.							
27-hour experiment	140	172	120	70	168	96	57
51-hour experiment	140	182	120	66	168	66	39
Lake Kilby, Virginia							
27-hour experiment	60	60	45	75	48	0	0

The following conclusions have been deduced from the results in the table.

1. The color colloids in all three waters showed negative characteristics when a current was passed *without* CO_2. Mr. Saville has demonstrated that this is the case with the majority of natural colored waters, particularly those which have had a period of storage.

2. The Black River water exhibited very feeble negative properties; the other two were distinctly negative in character. These results offer further evidence of the differences in the behavior of coloring matter which may be encountered in waters from different sources.

3. The addition of CO_2 increased the negative properties of the colloidal coloring matter in all three waters. The effect was most pronounced in the case of the Lake Kilby water, which showed absolutely no color in the negative arm of the tube after the experiment. In other words, all the color remaining carried a negative charge and migrated toward the positive pole. The effect of adding CO_2 to the other two waters was not as pronounced, but nevertheless was decided.

In what way, then, did CO_2 react to bring about a decrease in the percentage of positively charged coloring matter, and why was this decrease so much greater in the case of Lake Kilby water? The answer to these questions cannot as yet be given with entire confidence in the accuracy of their statement, but when it is considered that CO_2 dissolved in water bears a negative charge in the ionic condition, it is reasonable to suppose that it may enter into loose combination with, or be absorbed by, certain kinds of colloidal coloring matter, and that in so doing it imparts negative electrical properties to such colloidal particles. The extent to which this phenomenon occurs may well depend upon the nature of the colloids present. Some of them may not be susceptible to any such action. Others may behave in the manner of amphoteric substances and become positively or negatively charged according to the condition of the solution. Thus the Lake Kilby water may have contained colloidal coloring matter which was in part positively charged in the absence of CO_2, but which took on a negative charge in the presence of CO_2.

These experiments in some aspects have a bearing on practical matters. The Black River and Lake Kilby waters are both subjected to mechanical filtration with the use of alum as a coagulant. The latter water allows a high percentage removal of color per unit of alum used, and ordinarily exhibits very rapid coagulation with the formation of a coarse floc. In the experiments without addition of CO_2, the coloring matter of this water manifested negative properties. Inasmuch as the colloidal alum precipitate is positively charged, the negative charge on the color colloid is neutralized and the precipitation of both substances occurs.

The water tested in the laboratory was of necessity collected many days previously, and was practically devoid of CO_2. When CO_2 was added to Lake Kilby water, the negative properties were greatly increased, as previously mentioned. Such a condition would greatly augment the formation of a good coagulum with the positively charged aluminum colloid. As received at the filter plant, the water from the lake contains a very large amount of CO_2, and so in the light of the experiments described would conform to ideal conditions for coagulation.

The Black River water, on the other hand, frequently manifests very poor coagulation and may be classed as a difficult water to treat. Reference to the table of experimental results indicates that very weak negative properties were exhibited in the absence of CO_2. The charge on the colloidal particles of coloring matter in such a water would be neutralized only to a limited extent by the positively charged aluminum colloid, and as a result poor coagulation might be expected.

In the presence of CO_2, this water possessed stronger negative properties, but could not be compared with Lake Kilby water in this respect. Furthermore, as received at the plant for treatment, the water from the Black River does not carry anything like the content of CO_2 found in the water from Lake Kilby. To summarize, we have on the one hand a water distinctly negative in the absence of CO_2, entirely negative in the presence of this substance, carrying large amounts of CO_2 at its source, and giving satisfactory coagulation; on the other hand, a water weakly negative in the absence of CO_2, distinctly negative in the presence of CO_2, carrying only moderate amounts of this substance at its source, and offering difficulties in the way of coagulation.

This conception of the functions of CO_2 in intensifying the negative properties of color colloids is drawn from a very few experiments, but in the writer's mind it seems to fit the facts as observed. It is substantiated further by practical tests at certain filter plants where the addition of chemicals has been varied from standardized procedure in a manner that gives superior results at a lower cost.

In the *Engineering Record*, June 3, 1916, Mr. George F. Catlett described some experiments made at the Wilmington, N. C., mechanical filter plant. The application of his studies to the treatment of the water there resulted in marked improvement and an economy of over 50 per cent. in the use of chemicals.

The raw water at Wilmington is taken from the northwest branch of the Cape Fear River, a stream which drains a large area of cypress swamps and which possesses a very high color, 150 to 300 parts per million, and very little turbidity. Such is the character of the water at the plant at low tide. At high tide, water sets back from the main stream a short distance below. This stream is highly turbid and very low in color. As a consequence of the mixing, the raw water at the plant may contain at times of high tide from 30 to 50 parts per million of turbidity and perhaps 150 parts of color. Alum is used as a coagulant, and soda or lime to restore deficient alkalinity. The raw water seldom has more than 5 to 8 parts per million of alkalinity.

Under the old system of treatment, both the alum and soda were added before the water passed to the coagulation basins. The results were uncertain and unsatisfactory, the final effluent of the plant usually having a color of 40 to 100 parts per million, and containing more or less coagulant in a colloidal condition. Under the modified system, the alum is added as previously, together with just enough soda to allow an excess of $\frac{1}{4}$ grain per gallon of alum. The water is thus overdosed as it passes through the first basin. In the second basin, enough soda or lime is added to insure a final alkalinity of 10. Good coagulation and sedimentation result from the new procedure, the final effluent of the plant has a color of less than 10 and is free of colloidal particles of coagulant, and the alum has been reduced in amount from about 4 grains per gallon to 2 grains.

In the light of the experiments at Harvard, the Wilmington procedure is a rational one and the results obtained are consistent with the theories set forth in some of the preceding paragraphs. If alum is added to the water in sufficient amount to leave a slight excess, there will be liberated and left free in the water the maximum amount of CO_2 from the reaction between the alum and the alkalinity. On the other hand, if alkali is added with the alum, in order to maintain an alkaline condition, then part, or all, of the CO_2 will become fixed as bicarbonate.

It has already been shown that free CO_2 carries a negative charge on its ions and when present in a colored water tends to increase the negative properties of the color colloids. Consequently, when the colloidal particles of aluminum hydroxide are formed, their charge is neutralized by that of the colloidal color particles. Precipitation and flocculation are stimulated and we have efficient removal of color and turbidity. Mr. Catlett stated in the article referred to that the coloring matter of Wilmington water bears a positive charge, but in a later paper* says that experiments show it to be negative. From the standpoint of this discussion he has succeeded by means of the modified method of chemical treatment in preserving, and probably in intensifying, the negative properties of the Cape Rear River water until such a time as coagulation is complete.

Other experiments made at Wilmington in connection with the subsidence of turbidity also illustrate the negative properties imparted to water by CO_2. When lime was added to a water containing 160 parts per million of turbidity and 60 parts of color, in an amount sufficient to neutralize the CO_2, a very few hours sufficed to effect almost complete subsidence of the turbidity. Untreated water showed very slow precipitation. The experiments were conducted in jars, and no alum was added. Colloidal clay particles carry a negative charge. The presence of CO_2 tends to increase the stability of these suspensoids and prevents them from coming together to form aggregates. Removal of CO_2 decreases the stability, and when lime is used for the purpose it is also likely that there are formed small amounts of insoluble substances of a positively charged colloidal nature. These would

*American Public Health Association, Cincinnati Meeting, October, 1916.

neutralize the negative charge on the clay particles and thereby induce subsidence.

Valuable application of this method of treatment might be made in the case of a highly turbid, slightly colored water, lime being added before the alum. If a large amount of color is present, it is impracticable. The method would interfere with color removal just as it formerly did at Wilmington, when soda was added and the CO_2 fixed before coagulation was complete. In such a case, if turbidity persisted after color removal, lime might be added to the settled or partially settled water and the period of flow through the coagulation basins extended. This has been proposed at Wilmington.

The practice of "overdosing" colored water with alum was first brought to attention at Springfield, Mass., by Mr. Elbert E. Lochridge, and the method practiced there has been described by him in the *American Journal of Public Health*,* November, 1914. The water at this plant is filtered through slow sand filters after a long period of coagulation and sedimentation in a large natural basin. It was found that a greater reduction of color was obtained, with a smaller amount of alum, if alum was added in excess of the alkalinity for a period, and then discontinued for a period. This water has very little turbidity and a low alkalinity.

Various theories have been set forth to account for the improved results at Springfield. To the writer it seems that this must be due in a very large measure to the fact that the "overdose" of alum liberates a greater amount of CO_2 than the normal dose. This intensifies the negative character of the water and accelerates the precipitation of the colloidal aluminum compound. The charge carried by the excess alum may also stimulate this neutralization of colloidal color charges. Once the phenomenon of flocculation is actively started, the precipitation of the excess alum by the untreated portion of water which follows is rendered certain. The amount of CO_2 present during this secondary precipitation is of course much greater than would be the case if the amount of excess alum was added directly to raw water. Consequently, conditions are more favorable for coagulation. The alkalinity necessary for the final effluent is supplied by the water

* See also JOURNAL N. E. W. W. A., XXXI, p. 48.

which is not dosed directly. Only a small part of its bicarbonate alkalinity is neutralized by the excess alum in the dosed water, the balance imparting a permanent alkalinity to the water. There is no neutralization or "fixing" of the free CO_2 when alkalinity is supplied in this way, as the natural lime salt is already in the form of bicarbonate.

Problems of coagulation and color removal have continually vexed water-works men in connection with filtration. Some of these have been solved locally, but our basic knowledge of the true nature and properties of coloring matter has been too meager to allow the fomulation of practice which could be broadly applied. Laboratory experiments on the "dosing" of water have been made and repeated by the hundreds. They have served chiefly to stimulate speculation and theory, but their divergent results have confused rather than clarified conceptions regarding coloring matter and coagulation. It is evident that physical chemistry is really going to give us some definite information on these subjects. For that reason, it is important that the colloidal theory of coloring matter be put to every form of experimentation which our ingenuity may devise. Work in this field is attractive and worth while.

MR. SAVILLE (*by letter*). The chief aim of the present paper has been to present certain ideas relating to the nature of color in water, in the hope that water supply engineers and chemists would be able to obtain suggestions from which they might interpret the behavior of certain waters toward decolorization processes. The discussion by Messrs. Longley and Whipple is therefore particularly gratifying, in that they have each explained, on the basis of the colloidal theory, results obtained in the treatment of colored waters, the interpretation of which would otherwise be obscure.

Mr. Longley presents the interesting fact that of two waters of equal color, that which has been stored longest will, according to the colloidal theory of color in water, contain the largest color colloids. Hence it will be more readily decolorized by filtration than the other water stored for a shorter period. The experiments described on dialysis of colored waters and artificial colored extracts seem to substantiate the author's conclusions.

Mr. Whipple has supplemented the investigations of the author by studies of colored waters subjected to cataphoresis in the presence of CO_2. His observations are of particular importance in that he is enabled to explain on the basis of the colloidal theory certain results in color removal obtained by somewhat unusual procedures at both Wilmington, N. C., and Springfield, Mass.

These cities have used alum in removing color from their water supplies, but in both instances the process of treatment with alum has been novel and specialized. It was known that the ordinary methods of dosing with alum did not effect a satisfactory removal of color, and resort was had to special methods of treatment. It was not known (although it was inferred at Wilmington) just why the modified treatment worked successfully. The author believes that Mr. Whipple has satisfactorily explained this upon the colloidal theory and shown that the methods used are logical and proper for the particular waters in question.

It is by the acquirement of such definite knowledge as to the *why* of color removal practices that the colloidal theory offers the most immediate results. After further information has been gathered as to the cause and nature of color and the reactions involved in its removal, we may then hope to devise some new methods, or modifications of existing methods, of color removal which will be more satisfactory than those now used.

PROCEEDINGS.

December Meeting.

Hotel Brunswick, Boston, Mass.,
Wednesday, December 13, 1916.

President Sullivan in the chair.

The following members and guests were present:

Honorary Members.

Edwin C. Brooks.
Albert S. Glover.
Frank E. Hall. — 4.
R. C. P. Coggeshall.

Members.

S. A. Agnew.
L. M. Bancroft.
A. E. Blackmer.
J. W. Blackmer.
George Bowers.
J. M. Caird.
George Cassell.
J. C. Chase.
F. L. Cole.
J. M. Diven.
C. H. Eglee.
E. D. Eldredge.
G. F. Evans.
S. F. Ferguson.
F. L. Fuller.
Patrick Gear.
H. T. Gidley.
F. J. Gifford.
H. J. Goodale.
J. M. Goodell.
R. A. Hale.
R. K. Hale.
L. M. Hastings.
T. G. Hazard, Jr.
D. A. Heffernan.
Charles R. Hildred.
J. L. Howard.
A. C. Howes.
G. A. Johnson.
W. S. Johnson.
E. W. Kent.
Willard Kent.
G. A. King.
J. J. Kirkpatrick.
John Knickerbacker.
F. F. Longley.
E. J. Looney.
P. J. Lucey.
W. J. Lumbert.
Hugh McLean.
H. V. Macksey.
W. E. Maybury.
John Mayo.
Frank E. Merrill.
William Naylor.
T. A. Peirce.
H. G. Pillsbury.
E. W. Quinn.
G. A. Sampson.
P. R. Sanders.
C. M. Saville.
A. L. Sawyer.
J. E. Sheldon.
C. W. Sherman.
Sidney Smith.
G. H. Snell.
W. F. Sullivan.
W. C. Tannatt, Jr.
C. N. Taylor.
Milton Thorne.
A. H. Tillson.
E. J. Titcomb.
C. H. Tuttle.
W. H. Vaughn.
R. S. Weston.
L. J. Wilber.
F. B. Wilkins.
G. E. Winslow.
I. S. Wood.
M. B. Wright. — 70.

ASSOCIATES.

Harold L. Bond Co., H. H. Sinclair, F. M. Bates.
Builders Iron Foundry, F. N. Connet, A. B. Coulters, G. H. Lewis.
Darling Pump and Mfg. Co., Ltd., H. A. Snyder.
Eddy Valve Co., H. L. Prescott.
Fire and Water Engineering, Fred Shepperd.
Hersey Mfg. Co., Albert S. Glover, J. H. Smith.
Lead Lined Iron Pipe Co., T. E. Dwyer.
Macbee Cement Lined Pipe Co., J. P. MacBride.
H. Mueller Mfg. Co., G. A. Caldwell.
National Meter Co., J. G. Lufkin, H. L. Weston.
National Water Main Cleaning Co., B. B. Hodgman.
Neptune Meter Co., H. H. Kinsey.
Pitometer Co., E. D. Case.
Pittsburgh Meter Co., J. W. Turner.
Rensselaer Valve Co., C. L. Brown.
A. P. Smith Mfg. Co., F. L. Northrop.
Thomson Meter Co., E. M. Shedd.
Union Water Meter Co., E. K. Otis.
Water Works Equipment Co., W. H. Van Winkle.
R. D. Wood & Co., H. M. Simons.
Henry R. Worthington, E. P. Howard, Samuel Harrison. — 27.

GUESTS.

RHODE ISLAND.

East Greenwich, James Kinloch.

MASSACHUSETTS.

Attleboro, R. Bevenage.
Cambridge, Thorndike Saville.
Holyoke, P. E. Gear.
Northampton, C. P. Houghton.
North Andover, R. H. Ellis.

DOMINICAN REPUBLIC.

Santiago, W. J. Ryan. — 7.

In response to a call by the President, Commissioner Donnelly, of Lowell, opened the after-dinner exercises by singing several songs, which were enthusiastically applauded by the members, who, at the suggestion of Mr. Macksey, further expressed their appreciation of Mr. Donnelly's performance by a rising vote of thanks.

The Secretary presented applications for membership, properly endorsed and recommended by the Executive Committee, from the following:

Thorndike Saville, Cambridge, Mass., instructor in geology and sanitary engineering, Harvard University; Richard H. Ellis, superintendent Board of Public Works, North Andover, Mass.; Charles L. Crosier, Boston, Mass., assistant in civil engineering at Massachusetts Institute of Technology; Ernest H. Rigg, Woodbury, N. J., chairman of Water Committee, City Council;

James Menzies, Sydney, N. S., superintendent Water Works, city of Sydney.

On motion of Mr. Coggeshall, the Secretary was instructed to cast the ballot of the Association in favor of the applicants, and he having done so they were declared elected members of the Association.

Mr. R. A. Hale. I want to call the attention of the members to a new publication which has just been issued by the Geological Survey, on the surface waters of Massachusetts. It has been compiled by C. H. Pierce and H. J. Dean, of the United States Geological Survey, in coöperation with the state of Massachusetts. It comprises a volume of about 430 pages, giving the flows of all the principal rivers and the records of some 35 gaging stations. The Lowell period is from 1848 up to the present time. We have the flow of the Merrimack River at Lawrence for thirty-five years, and the Deerfield and Concord rivers, and a great many other rivers are covered for different periods. It will be of great value to water-works, sanitary, and hydraulic engineers in determining the probable water supplies and the flow of the streams.

Mr. Pierce has been compiling a mailing list, so far as he knows, of men who are interested, and I thought I would make the announcement to-day that, if any one would like a copy, if he will notify Mr. C. H. Pierce at the Custom House Building, Boston, he will be very glad to put his name on the list and send him a copy. The publication is No. 415 of the Water Supply papers of the Geological Survey. I don't know how large an edition is being issued, but I should recommend those who wish to get a copy to send reasonably early, because such editions are at times exhausted. It is certainly a very valuable publication, and a great deal of work has been put into it. Another year there will be a supplementary report issued covering similar ground, and if any superintendents or engineers have the flows of streams or water-works data which they could send him, it would be very acceptable in preparing a complete record of the flows of Massachusetts and the New England states.

President Sullivan. I wonder if "Eglee's" is out for this week? In these strenuous times he ought to have something to say.

MR. CHARLES H. EGLEE.* In these "strenuous times," as our President has termed them, you want some one to speak to you who will take the edge off of the strenuosity; and when you call on Eglee to speak, you want him to say something that will be light and cheerful and happy and foolish and frivolous. But I do not feel at all like speaking along those lines to-day.

Mr. President, I think in these "strenuous times" it is not wise to blunt our feelings to the momentous questions that are continually arising, and I believe that there has been something put before us, in the daily papers of yesterday and to-day, that every thoughtful man in this country ought to stop and consider. And if you will give me five minutes, we will think a little on this question of "peace." I don't know whether you want any such question intruded upon this meeting or not, but I have been thinking about it for several hours, and it seems to me I have a good chance to ventilate myself right now while you can't help yourselves.

We want peace. We want peace in our personal lives; we want peace in our business lives; we want peace in our national lives; and we want to see the warring nations stop this furious combat; but we don't want to see any sort of peace in our lives, in our business nor in the nations, unless that peace is a *right* peace. I am thoroughly in accord with the sentiment voiced by Mr. Beck two nights ago, at the Pennsylvania dinner, that there is something that is greater than peace, and that is honor, national honor; but we have seen all these nations abroad doing all the things that they possibly can do against their own national honor. I don't know where to put a finger on a lovely spot in this war. The efficiency of Germany, so great, has led her people into a condition where they are under a military domination that all of them cannot accept. Russia, with its beautiful simplicity of character, is under the selfish rule of a grafting nobility. England's aggressiveness and selfishness have carried her into all portions of the globe, and she can't help monkeying with our mails at the present time. I don't know that there is anything to be said about France, excepting in admiration of the virility and thrift of her people. These nations are all fighting furiously. They can't

* Hydraulic Engineer, Brookline, Mass.

get together, yet they say they want to have peace, and we in this country don't seem to want them to be at peace. Why, the "war brides" we have been flirting with are to-day indisposed, and the "babies" we have been bringing up are in convulsions.

We may talk about the peace of Europe, but does it not depend a very great deal upon this country? Because we see so many nations exhibiting their worst traits at the present time, it doesn't mean that they haven't good traits. That delightful simplicity of the Russian character that has been exploited so long; that wonderful thrift and virility of the French I have spoken of; that determined and dogged perseverance of the English people; that wonderful efficiency of the Germans, — how are all those excellent qualities to be brought together? How are they going to make a peace that will be lasting, not a truce that shall merely be a preparation for a war thirty or forty or may be ten years from now? They are going to do it through this country, because we have taken all these various qualities, welded them and amalgamated them and brought them into some sort of national spirit here. And yet we too are to-day exhibiting the worst side of our character through this ugly war, seeming to care only about how much money we are going to make out of it. This is a pity, because the time is coming when the national character of the American people must be used in helping to procure this honorable peace that shall last for the next thousand years.

And how are we going to do it? We are going to do it by an expression of the righteous opinion of the American people. It is up to you, and it is up to me, and it is up to the individuals of this community and of other communities of the states and of the nation, to think about these things and mark out a straight course, not by way of expediency but by the way of principle. We can never have peace in our lives unless we have determined upon a principle and have followed that principle. And it is up to us who have taken in and made use of all these various characteristics of all these various peoples, and have shown what we can do with them in the mass, to think through this question and to determine that principle of honorable peace that we at the proper time can lay before the other peoples for their consideration. It will not do that this country shall say, We are not concerned with

the causes of this war. There was a man once who was asked what became of his brother, and he said, "Am I my brother's keeper?" We have been in a mess about that ever since, and we will be in a mess to-day if we say that same thing again. We *are* concerned, and it is up to us, before we get through, to do the right thing and not the expedient thing. I will leave that thought in your minds, gentlemen.

The paper on the program for the afternoon was by Mr. Thorndike Saville, of Cambridge, Mass., and the subject was, "The Nature of Color in Water." It was discussed by Professor Whipple, Mr. Johnson, and Mr. Francis F. Longley.

Mr. Robert Spurr Weston, consulting engineer, Boston, Mass., gave an interesting illustrated talk on "Water Works in Cuba, and Other Things."

Adjourned.

Annual Meeting.

Hotel Brunswick,
Boston, Mass., January 10, 1917.

The President, Mr. William F. Sullivan, in the chair.

The following members and guests were present:

Honorary Members.

Edwin C. Brooks. Frank E. Hall. Robert J. Thomas. — 4.
Albert S. Glover.

Members.

R. C. Allen.	R. H. Ellis.	H. A. Hanscom.
L. M. Bancroft.	E. D. Eldredge.	L. M. Hastings.
F. A. Barbour.	G. H. Finneran.	T. G. Hazard, Jr.
A. E. Blackmer.	John Franklin.	D. A. Heffernan.
J. W. Blackmer.	F. L. Fuller.	C. R. Hildred.
George Cassell.	Patrick Gear.	J. L. Howard.
F. M. Cole.	H. T. Gidley.	A. C. Howes.
A. W. Cuddeback.	F. J. Gifford.	E. F. Hughes.
John Cullen.	X. H Goodnough.	G. A. Johnson.
C. E. Davis.	F. H. Gunther.	W. S. Johnson.
A. O. Doane.	R. A. Hale.	F. T. Kemble.
John Doyle.	R. K. Hale.	E. W. Kent.

Willard Kent.
S. E. Killam.
G. A. King.
John Knickerbacker.
G. H. Leland.
W. J. Lumbert.
P. J. Lucey.
Thomas McKenzie.
Hugh McLean.
A. E. Martin.
W. E. Maybury.
F. E. Merrill.
G. F. Merrill.
Leonard Metcalf.
Hiram A. Miller.
William Naylor.
T. A. Peirce.
H. E. Perry.
A. E. Pickup.
H. G. Pillsbury.
C. R. Preston.
Henry Richards.
L. C. Robinson.
B. F. Rogers.
A. T. Safford.
C. M. Saville.
Thorndike Saville.
J. E. Sheldon.
C. W. Sherman.
E. C. Sherman.
M. A. Sinclair.
J. Waldo Smith.
Sidney Smith.
G. H. Snell.
O. H. Starkweather.
W. M. Stone.
G. A. Stowers.
W. F. Sullivan.
H. A. Symonds.
E. A. Taylor.
Milton Thorne.
L. D. Thorpe.
J. L. Tighe.
E. J. Titcomb.
D. N. Tower.
C. H. Tuttle.
W. H. Vaughn.
J. H. Walsh.
R. S. Weston.
R. M. Whittet.
F. B. Wilkins.
H. F. P. Wilkins.
F. I. Winslow.
I. S. Wood.
Edward Wright.
M. B. Wright.
C. W. Young. — 93.

ASSOCIATES.

Harold L. Bond Co., H. H. Sinclair, F. M. Bates.
Builders Iron Foundry Co., A. B. Coulters, G. H. Lewis.
Central Foundry Co., W. H. Felt, R. W. Conrow.
Eddy Valve Co., H. R. Prescott.
Fire and Water Engineering, Fred Shepperd.
F. H. Hayes Machinery Co., F. H. Hayes.
Hersey Mfg. Co., Albert S. Glover, W. A. Hersey, J. Herman Smith.
Lead Lined Iron Pipe Co., T. E. Dwyer.
Ludlow Valve Mfg. Co., A. R. Taylor.
H. Mueller Mfg. Co., G. A. Caldwell.
National Meter Co., J. G. Lufkin.
Neptune Meter Co., H. H. Kinsey, R. D. Wertz.
Pittsburgh Meter Co., J. W. Turner.
Rensselaer Valve Co., C. L. Brown.
Thomson Meter Co., E. M. Shedd, S. D. Higley.
Union Water Meter Co., D. K. Otis, F. E. Hall.
United States Cast Iron Pipe & Foundry Co., C. Donaldson.
Warren Foundry & Machine Co., J. H. Morrison.
Water Works Equipment Co., W. H. Van Winkle.
R. D. Wood & Co., H. M. Simons.
Henry R. Worthington, Samuel Harrison, W. F. Bird, E. P. Howard. — 31.

GUESTS.

NEW HAMPSHIRE.

Nashua, Mayor James B. Crowley; John H. Stark, president Pennichuck Water Works.
Concord, T. W. D. Worthen, Public Service Commission.

MASSACHUSETTS.

Holyoke, Daniel Long, P. E. Pear.
Boston, Martin R. Lane, W. O. Teague.
Billerica, Frank L. Day.

RHODE ISLAND.

East Greenwich, James Kinlock.

NEW YORK.

New York, A. H. Howard. — 10.

The Secretary presented applications for active membership, properly endorsed and recommended by the Executive Committee, as follows:

William H. O'Brien, Chicopee, Mass., foreman Chicopee Water Department; John F. Sullivan, Chicopee, Mass., superintendent Chicopee Water Department; C. A. Stevens, Cummington, Mass., water commissioner; Dudley Chipley, Columbus, Ga., engineer and superintendent Columbus Water Works.

On motion, the Secretary was directed to cast the ballot of the Association in favor of the applicants named, and, he having done so, they were declared duly elected members of the Association.

PRESIDENT SULLIVAN. Mr. Edward C. Niles, chairman of the Public Service Commission of New Hampshire, is unable to be with us to-day, but happily we have an associate of his from the Commission. Within a few years many states in the Union have created public service commissions, and the men appointed on these commissions have been able, broad-gaged, fair, and judicial, and the public and the public service corporations were indeed fortunate in having the states make laws creating public service commissions. These public service commissions protect the public against grasping corporations, and they certainly act as a buffer between the public and the public service corporations. They are a protection to the public and they are a greater protection, I believe, to the public service corporations, because they deal out justice to them, and that is all they desire. Commissions have a difficult and intricate work before them, broadening all the time. When you think of the railroads, street railways, water, gas, electricity, and telephone problems which they have to solve and do the just and fair thing for everybody, for both sides, you can

imagine the job they have. It is a big job. It is a man's job. And we are fortunate to-day in having with us Prof. Thomas W. D. Worthen, member of the Public Service Commission of New Hampshire, who will talk to us on "Public Service Regulation and Control." I believe it is almost inevitable that regulation and control by commissions must broaden out from the public service corporations to the publicly operated utilities.

On motion of Mr. George Cassell, a rising vote of thanks was extended to the speaker.

Professor Worthen's paper was discussed by Mr. Leonard Metcalf.

The Association next listened to a paper entitled, "The First Slow Sand Filter in the State of Maine," by Henry Richards, trustee Gardiner Water District, Gardiner, Me., the paper being discussed by Mr. A. T. Safford.

The President read the report of the Executive Committee.

Report of the Executive Committee.

Boston, Mass., January 10, 1917.

Early in the year, a Membership Committee was appointed, with Mr. R. C. P. Coggeshall chairman, and Mr. W. S. Johnson secretary. Immediately this committee set to work to increase our membership, and it did effective work, Mr. Johnson devoting much time and thought in an effort to reach many who are eligible.

The membership to date is	1 043
Initiated, reinstated, and qualified	150
Resigned and dropped	60
Died	8
Net gain in members	82

It is with regret we record the deaths of one honorary member and seven active members, as follows: E. D. Leavitt, George E. Crowell, J. W. Ellis, W. H. Jacques, G. L. Learned, T. H. McKenzie, D. A. Sutherland, and E. L. Peene.

The Boston meetings have been held regularly, as provided for by the constitution. These meetings have been a success socially and educationally. The June field day, like the one of the previous year, took the form of a joint outing with the Boston Society

Year.	President.	Membership at End of Year.				Annual Convention.		Receipts for Year.	Expenditures for Year.	Total Balance at End of Year.
		Members.	Associate.	Honorary.	Total.	Place.	Date.			
1882	(Organized)	27	—	—	27	Boston, Mass.	June 21, '82			
1882–3	*James W. Lyon	37	6	—	43	Worcester, Mass.	June 21, '83	$245.00	$87.86	$157.14
1883–4	Frank E. Hall	48	9	—	57	Lowell, Mass.	June 19–20, '84	156.14	171.90	141.38
1884–5	*George A. Ellis	83	44	—	127	Springfield, Mass.	June 18–19, '85	651.84	511.44	281.78
1885–6	R. C. P. Coggeshall	106	47	—	153	New Bedford, Mass.	June 16–18, '86	1 658.50	1 643.42	296.86
1886–7	*Henry W. Rogers	137	52	2	191	Manchester, N. H.	June 15–17, '87	1 342.28	1 066.98	572.16
1887–8	*Edwin Darling	181	54	3	238	Providence, R. I.	June 13–15, '88	2 013.30	1 697.15	888.31
1888–9	*Hiram Nevons	209	64	4	277	Fall River, Mass.	June 12–14, '89	2 204.07	2 127.70	964.68
1889–90	*Dexter Brackett	257	73	5	335	Portland, Me.	June 11–13, '90	2 511.27	2 346.65	1 129.30
1890–1	*Albert F. Noyes	281	74	5	360	Hartford, Conn.	June 10–12, '91	3 055.13	1 884.78	2 299.65
1891–2	*Horace G. Holden	290	70	5	365	Holyoke, Mass.	June 8–10, '92	2 887.17	3 278.54	1 908.28
1892–3	*George F. Chace	338	69	5	412	Worcester, Mass.	June 14–16, '93	3 422.61	3 317.22	2 013.67
1893–4	*Geo. E. Batchelder	365	73	5	443	Boston, Mass.	June 14–16, '94	3 208.85	3 259.07	1 963.45
1894–5	George A. Stacy	401	81	5	487	Burlington, Vt.	Sept. 11–13, '95	3 147.41	3 115.99	2 673.03
1895–6	Desmond FitzGerald	442	82	5	529	Lynn, Mass.	June 10–12, '96	3 179.91	3 148.49	2 704.45
1896–7	*John C. Haskell	464	80	5	549	Newport, R. I.	Sept. 8–10, '97	3 340.23	3 322.94	2 271.74
1897–8	Willard Kent	488	77	5	570	Portsmouth, N. H.	Sept. 14–16, '98	3 002.13	2 786.95	2 936.92
1898–9	Fayette F. Forbes	494	73	5	572	Syracuse, N. Y.	Sept. 13–15, '99	2 825.71	3 050.23	2 712.40
1899–1900	Byron I. Cook	519	70	5	594	Rutland, Vt.	Sept. 19–20, '00	4 920.49	5 524.65	2 108.24
1901	Frank H. Crandall	493	58	4	555	Portland, Me.	Sept. 18–20, '01	4 238.55	4 283.22	2 063.57
1902	Frank E. Merrill	522	60	5	587	Boston, Mass.	Sept. 10–12, '02	5 158.48	4 680.32	2 541.73
1903	*Charles K. Walker	520	55	3	586	Montreal, Canada	Sept. 9–11, '03	5 032.40	4 505.08	3 069.05
1904	Edwin C. Brooks	538	58	8	604	Holyoke, Mass.	Sept. 14–16, '04	5 328.31	5 528.21	2 869.15
1905	George Bowers	584	53	8	645	New York, N. Y.	Sept. 13–16, '05	5 431.16	5 411.58	2 888.73
1906	Wm. T. Sedgwick	618	51	15	684	White Mts., N. H.	Sept. 12–14, '06	5 366.94	4 845.14	3 410.53
1907	John C. Whitney	636	51	15	692	Springfield, Mass.	Sept. 11–13, '07	5 291.83	4 222.06	4 480.30
1908	Alfred E. Martin	633	49	14	696	Atlantic City, N. J.	Sept. 23–25, '08	5 706.36	7 475.56	†2 711.10
1909	Robert J. Thomas	647	55	13	715	New York, N. Y.	Sept. 8–10, '09	5 305.31	4 566.84	†3 449.57
1910	George A. King	678	56	13	747	Rochester, N. Y.	Sept. 21–23, '10	6 507.08	7 237.60	†2 719.05
1911	Allen Hazen	680	58	12	750	Gloucester, Mass.	Sept. 13–15, '11	6 440.90	6 279.72	†2 880.23
1912	Geo. W. Batchelder	666	53	12	731	Washington, D. C.	Sept. 18–20, '12	6 861.65	5 934.56	†3 807.32
1913	J. Waldo Smith	686	60	12	758	Philadelphia, Pa.	Sept. 10–12, '13	6 122.81	6 533.62	†3 396.51
1914	Frank A. McInnes	766	70	11	847	Boston, Mass.	Sept. 9–11, '14	7 686.17	7 437.17	†3 645.51
1915	Leonard Metcalf	862	81	18	961	New York, N. Y.	Sept. 7– 9, '15	7 338.56	8 569.16	†2 414.91
1916	William F. Sullivan	942	84	17	1043	Portland, Me.	Sept. 13–15, '16	9 022.09	9 017.43	†2 419.57

*Deceased. †Does not include $1 815 invested in bonds.

of Civil Engineers. A delightful sail and dinner, with an entertainment, gave our members much enjoyment. The Boston Society of Civil Engineers on this occasion had as an honored guest Admiral Robert E. Peary, who talked to us in a most interesting and instructive way on "Preparedness." The day was featured by a "red-hot" ball game between the Society and the Association, and it was our pleasure to see the New England boys wallop the Engineers.

The Annual Convention at Portland, Me., was a great success in attendance and in interest. The business sessions were unusually well attended. Discussions were general, and provoked a lively interest. The topics discussed were timely and of great value to our members. The outings provided by the committee, headed by Mr. W. S. Johnson, were splendid affairs, a continuous round of festivity, run off on schedule time. These outings gave our members an opportunity to view the beautiful city and harbor and the excellent water supply of Portland. The hospitality of the "Forest City" was genuine and hearty.

The papers and talks this year have been of the usual high standard of excellence. They have been instructive and enjoyable.

A number of committees have been appointed on special subjects this year. The personnel of these committees promises much valuable information on questions and policies pertaining to our work.

The Committee on Meter Rates, Allen Hazen, chairman, has made its final report, which has been accepted. This report makes an important contribution to water-works literature.

The Committee on Standard Hydrant Specifications has not as yet made its final report.

The Committee on Brackett Memorial has completed the work assigned to it. This report and the recommendations it contained have been adopted by the Association. Great care in the future must be exercised in carrying out the provisions of this report.

The other special committees are devoting time and work to the matters in hand, and we are assured when we receive the reports and when these reports are spread on our records, the members of this Association will have material of great value.

This year the JOURNAL has maintained the high place it holds among publications of this kind. Early in the year our Editor, Major Richard K. Hale, responded to the call for troops on the Mexican border. Happily, he has now returned. During his absence the Board of Editors were fortunate in securing the services of Mr. Edward C. Sherman who, although suddenly called upon to assume the task, did it with zeal and carried the work along with efficiency and dispatch.

This year there was issued, at a net expense of $591.04, a complete index to our JOURNAL. This volume contains an author's index and a subject index. This index will be of great assistance to our members.

This year the Executive Committee voted jointly with the Boston Society of Civil Engineers to rent an additional room for headquarters purposes. The extra room will furnish the Association with much-needed facilities and will enable the Assistant Secretary to transact the rapidly growing business much more efficiently. A joint committee has agreed upon terms and furnishings.

Owing to the increased work performed by the Assistant Secretary, the Executive Committee voted unanimously to increase the salary of this position from six hundred to eight hundred dollars per year.

The financial statement of the Association is shown in the report of the Treasurer.

Your Executive Committee has considered the matter of increasing our income. A special committee, with our advertising agent, Mr. Geo. A. King, as chairman, is to make an effort to enlarge the scope of our JOURNAL as an advertising medium. We all feel that our JOURNAL offers exceptional opportunities to advertisers, and we would urge our members to assist this committee and to show to advertisers that the JOURNAL's index to advertisers is often referred to when buying materials and supplies. We need your support to convince non-advertisers that the JOURNAL is not only read and kept on file, but is considered of great value when one seeks the names and addresses of manufacturers. Will you coöperate with this committee so that the advertising columns of the JOURNAL may be made more useful to our members and more profitable to the advertisers?

The Secretary, Mr. Willard Kent, presented his annual report.

Report of the Secretary.

January 1, 1917.

Mr. President and Gentlemen of the New England Water Works Association,—
The Secretary submits herewith the following report of the changes in membership during the past year, and the general condition of the Association.

The present membership is 1 043, constituted as follows: 17 Honorary, 942 Members, and 84 Associates. That of one year ago was 961, comprised of 18 Honorary, 862 Members, and 81 Associates. A net gain for the year of 82. The detailed changes are as follows:

MEMBERSHIP.

January 1, 1916.	Honorary Members		18		
	Died		1		
			—		17
January 1, 1916.	Total Members			862	
	Resigned		20		
	Dropped		30		
	Died		7		
			—	57	
				—	805
	Initiations:				
		January	9		
		February	8		
		March	5		
		June	65		
		September	35		
		November	7		
		December	3		
			—		132
	Reinstated:				
		Member resigned '04	1		
		Member resigned '16	1		
			—	2	
		Elected 1914, qualified 1916		2	
		Elected 1915, qualified 1916		1	
				—	5
					— 942
January 1, 1916.	Total Associates			81	
	Resigned		7		
	Dropped		3		
			—	10	
				—	71

Initiations:				
February	1			
March	1			
June	1			
September	9			
	—	12		
Reinstated:				
Associate resigned, 1906		1		
		—	13	
			—	84
January 1, 1917. Total membership				1 043
January 1, 1916. Total membership				961
Net gain				82

The Secretary has received and paid to the Treasurer, $7 689.71.
Of this amount the

Receipts for initiation fees were	$682.00		
From dues of members	2 471.00		
From dues of members, fractional	195.00		
From dues of members, past	4.00		
		$3 352.00	
From dues of Associates	$1 115.00		
From dues of Associates, fractional	78.75		
		1 193.75	
Total from dues			$4 545.75
From advertisements			1 765.00
From subscriptions			231.00
From JOURNALS			265.50
From sundries			882.46
Total as above			$7,689.71

There is due the Association at this date:

For advertising	$78.75
For specifications	10.00
For certificate	7.50
For subscription	18.00
For JOURNAL	4.00
Total amount due	$118.25

Respectfully submitted,

WILLARD KENT, *Secretary.*

The Treasurer, Mr. Lewis M. Bancroft, submitted the following report:

CLASSIFICATION OF RECEIPTS AND EXPENDITURES.

Receipts.

Dividends and interest		$140.57
Initiation fees	$682.00	
Dues	3 863.75	
Total received from members		4,545.75
JOURNAL:		
Advertisements	$1 765.00	
Subscriptions	231.00	
Sale of JOURNALS	265.50	
Sale of Reprints	26.15	
Total received from JOURNAL		2 287.65
Miscellaneous receipts:		
Sale of "Pipe Specifications"	$32.70	
Dinners	708.00	
Certificates of membership	81.00	
Buttons	6.00	
Index	4.00	
Dexter Brackett Memorial Committee	197.34	
Manufacturers Association	1 000.00	
Miscellaneous	19.08	
Total miscellaneous receipts		2 048.12
Total receipts		$9 022.09

Expenditures.

JOURNAL:		
Advertising Agent's commission	$239.00	
Plates	97.61	
Printing	2 066.99	
Editor's salary	225.00	
Expense	35.25	
Advance reports	131.46	
Reporting	242.20	
Reprints	225.15	
Envelopes and postage	78.48	
		$3 341.14

LEWIS M. BANCROFT, *Treasurer*,

In account with the New England Water Works Association.

RECEIPTS.			EXPENDITURES.		
1916.					
Jan. 1.	Balance on hand	$2 414.91	Bills paid		$8 017.43
	Received of Willard Kent, Secretary	7 689.71	Paid Treasurer Convention Committee		1 000.00
	Interest on bonds and deposits	135.04	BALANCE ON HAND.		
	Brackett Memorial Committee	197.34	People's Savings Bank	$2 000.00	
	Manufacturers' Association	1 000.00	Mechanics Savings Bank	388.00	
			First National Bank	20.33	
			Liberty Trust Co	11.24	
					2 419.57
		$11 437.00			$11 437.00

ASSETS AND LIABILITIES.

ASSETS.			LIABILITIES.	
Cash balance in banks		$2 419.57	Accounts payable:	
Bonds Nos. 2642 and 2644, Lake Shore & Mich. Southern R. R. 4%, due May 1, 1931. Book value, $1 815.00. Market value		1 920.00	Samuel Usher	$579.24
Accounts receivable:			D. Gillies Sons	37.45
JOURNALS	$4.00		S. M. James	49.60
Advertising	78.75		Surplus	3 791.53
Subscriptions	18.00			
Certificates	7.50			
Specifications	10.00			
		118.25		
		$4 457.82		$4 457.82

READING, January 8, 1917.

LEWIS M. BANCROFT, *Treasurer.*

Office:			
Secretary, salary		$200.00	
Expense		27.40	
Assistant Secretary, salary		800.00	
Expense		372.12	
Rent		404.17	
Printing, stationery, and postage		279.68	
Membership lists		191.00	
			$2 274.37
Meetings and Committees:			
Stereopticon		$40.00	
Dinners	$744.20		
Cigars	51.00		
Music	121.00		
		916.20	
Printing, stationery, and postage		862.62	
Badges		108.57	
Banners		8.00	
June outing		3.48	
Traveling expenses		59.00	
Reporting		108.70	
			2 106.57
Treasurer's salary and bond			67.50
Certificates of membership			25.81
Pipe specifications			30.50
Index			151.00
Miscellaneous			20.54
Convention Committee			1 000.00
			$9 017.43

The Editor, Mr. Richard K. Hale, reported as follows:

Report of the Editor.

Boston, January 10, 1917.

To the New England Water Works Association, — I present the following report for the Journal of the New England Water Works Association for the year 1916.

The accompanying tabulated statements show in detail the amount of material in the Journal; the receipts and expenditures on account of Volume 30 of the Journal, and a comparison with the conditions of preceding years.

Size of Volume. — The volume is somewhat larger than average.

Illustrations. — The total cost of illustrations for the year, including printing, has been $224.26, or 6.6 per cent. of the gross cost of the volume.

Reprints. — The usual fifty reprints of papers have been furnished to authors without charge, and additional reprints, when desired, at the cost of the paper and press work. The net cost to the Association for reprints has been $174.25. There have been advance copies of ten papers prepared during the year, at a cost of $137.46.

Circulation. — The present circulation of the JOURNAL is:

Members, all grades	1 043
Subscribers	83
Exchanges	29
Total	1 155

an increase of 76 over the preceding year. JOURNALS have also been sent to 43 advertisers.

Advertisements. — There has been an average of 25 pages of paid advertising, with an income of $1 698, a slight decrease over last year.

Pipe Specifications. — During the year the specifications for cast-iron pipe to the value of $32.70 have been sold; 500 were printed at a cost of $30.50. The net gain up to a year ago had been $294.25, so that the total net gain from this source to date is $296.45. There are still about 300 copies of specifications on hand, or about $30.00 worth if sold at retail.

The Association has a credit of $8.99 at the Boston Post-Office, being the balance of the money deposited for payment of postage upon the JOURNAL at pound rates.

Index. — An index of the JOURNAL and of Transactions, covering the years 1882 to 1915 inclusive, was published during the current year at a net cost of $591.04.

During the absence of the Editor from the state this summer, Mr. Edward C. Sherman took over the duties of that office.

Respectfully submitted,

RICHARD K. HALE, *Editor.*

TABLE 1.

STATEMENT OF MATERIAL IN VOLUME XXX, JOURNAL OF THE NEW ENGLAND WATER WORKS ASSOCIATION, 1916.

Number.	Date.	Pages of								Total Cuts.
		Papers.	Proceedings.	Total Text.	Index.	Advertisements.	Cover and Contents.	Insert Plates.	Total.	
1	March	142	40	182	..	32	4	9	227	26
2	June	106	12	118	..	32	4	4	158	16
3	September	111	1	112	..	32	4	2	150	13
4	December	66	60	126	8	32	4	2	172	2
	Total	425	113	538	8	128	16	17	707	57

TABLE 2.

RECEIPTS AND EXPENDITURES ON ACCOUNT OF VOLUME XXX, JOURNAL OF THE NEW ENGLAND WATER WORKS ASSOCIATION, 1916.

Receipts.		*Expenditures.*	
Advertisements	$1 692.50	Printing JOURNAL	$1 997.98
Sale of JOURNALS	265.50	Printing illustrations	101.96
Sale of Reprints	25.65	Preparing illustrations,	122.30
Subscriptions	231.00	Editor's salary	300.00
	$2 214.65	Editor's incidentals	46.33
Net cost of JOURNAL	1 171.98	Advertising Agent's commission	238.50
		Reporting	242.20
		Reprints	199.90
		Advance copies	137.46
	$3 386.63		$3 386.63

TABLE 3.

Comparison between Volumes XXI to XXX, Inclusive, New England Water Works Association.

	Vol. XXI. 1907.	Vol. XXII. 1908.	Vol. XXIII. 1909.	Vol. XXIV. 1910.	Vol. XXV. 1911.	Vol. XXVI. 1912.	Vol. XXVII. 1913.	Vol. XXVIII. 1914.	Vol. XXIX. 1915.	Vol. XXX. 1916.
Average edition (copies printed)	1 085	1 000	1 000	1 150	1 000	1 000	1 000	1 050	1 325	1 500
Average membership	693	699	710	732	752	740	745	803	904	1 002
Circulation at end of year	785	780	802	827	840	826	858	951	1 079	1 155
Pages of text	500	500	459	643	475	401	554	564	596	538
Pages of text per 1 000 members	722	715	646	880	632	542	746	702	659	538
Total pages, all kinds	669	681	627	808	654	567	733	719	776	707
Total pages per 1 000 members	964	976	884	1 090	870	766	984	895	859	707
Gross Cost:										
Total	$2 643.42	$2 733.61	$3 111.15	$3 490.81	$2 625.87	$2 476.55	$3 586.29	$3 345.87	$4 243.35	$3 386.63
Per page	3.95	4.01	4.97	4.32	4.02	4.37	4.89	4.65	5.47	4.79
Per member	3.82	3.91	4.39	4.78	3.50	3.35	4.81	4.17	4.68	3.38
Per member per 1 000 pages	5.70	5.88	7.00	5.90	4.09	5.90	6.46	5.80	6.02	4.79
Per member per 1 000 pages text	7.62	8.02	9.56	7.44	7.36	8.35	8.68	7.39	7.85	6.30
Net Cost:										
Total	$483.15	$131.06	$789.98	$1 334.06	$352.82	$98.81	$1 322.90	$1 155.33	$2 091.09	$1 171.98
Per page	.72	.19	1.26	1.65	.54	.17	1.80	1.61	2.70	1.65
Per member	.70	.19	1.11	1.82	.47	.13	1.78	1.44	2.32	1.17
Per member per 1 000 pages	1.04	.28	1.78	2.25	.55	.23	2.42	2.00	2.98	1.65
Per member per 1 000 pages text	1.39	.39	2.43	2.83	.98	.33	2.38	2.55	3.88	2.17

The Auditing Committee submitted the following report:

REPORT OF AUDITING COMMITTEE.

BOSTON, MASS., January 8, 1917.

We have examined the accounts of the Secretary and Treasurer of the New England Water Works Association, and find the books correctly kept and the various expenditures of the past year supported by duly approved vouchers.

Respectfully submitted,

GEO. H. FINNERAN,
D. N. TOWER,
Auditing Committee.

(On motion duly made, it was voted that the reports read be accepted and spread upon the records in the JOURNAL.)

Mr. William F. Sullivan, the retiring President, then made his address.

PRESIDENTIAL ADDRESS.

Delivered before the New England Water Works Association, January 10, 1917, by William F. Sullivan.

The year 1916 has been a wonderful one for big business. Industries have been more prosperous than ever before in their history. Many concerns once struggling for existence have been obliged to run their plants to the limit. So the year just closed has been an extraordinary one for water-works managers.

Unusual and unnatural economic conditions have been brought about by the press of general business prosperity. Prices have increased in almost all directions. Needed supplies have soared in price to such heights as to have counseled prudence in the early months of the year. Some of us were convinced that it would be good policy as well as good business to mark time on large purchases and to delay construction. While discretion said " Wait," a portion of the public would not.

People with money or credit, spurred on by increased wages and flushed by what appears to be factitious prosperity, cast aside their usual thrift and ideas of economy and went ahead with new construction regardless of the cost. The result of this boom building has been the pyramiding of demands on labor and ma-

terials. I do not believe any one would say that this activity is not good for a community. But, to meet the requirements, utilities have been compelled to follow after this development and at times speculative craze. Naturally, the most needed conveniences to round out and complete this work are improved streets, sidewalks, water, sewers, and lighting, the most needful of these being water. Owners and promoters usually have been able to exert an influence to have the water supply extended to their premises regardless of current costs. It goes without saying that it is the duty and is usually the policy of all utilities to meet these obligations if reasonable. Water departments and water companies, however, cannot go on *ad infinitum* in the quest of new business without adequate compensation.

The returns to-day are based on previous costs of work and service, and are out of proportion to present-day costs and expenses. The tentative resolution which some of us took, early in the year, to mark time, was soon broken, and we have been in a way compelled to go ahead and lay pipes at a cost which thirty months ago we would have considered almost prohibitive.

Current prices are primarily due to the scarcity of labor, with the resultant increase in wages, and to the scarcity of raw materials. Minimum increase in cost of labor has been 25 per cent., cast-iron pipe 40 per cent., and in other supplies 30 per cent. Equipment and supplies which were formerly sold at discounts from time-honored lists are now in many cases plus such lists. Even with high prices the rule, it has been difficult to obtain the goods, and slow deliveries have become the custom.

Car shortage and embargoes on pipe and bulk freight have often delayed necessary work, especially work planned to be completed before weather conditions became too severe, such work having been started with the reasonable expectation of early deliveries. The result of this hold-up has been open trenches which have required lighting and care, frozen backfilling, increasing the cost. The railroads have been unyielding on their embargoes, which have seriously militated against the business interests of New England. Embargoes on shipments of cast-iron pipe have been in force over two months at a time. This delay, coming in the fag end of the year, has been a real hardship. Efforts for relief

have been futile, and thus we have been paying in money and inconvenience for conditions brought about by the European war.

Notwithstanding high costs, the nation's business has been prosperous, and most industries have been able to meet the changed conditions by automatically raising the prices of their products. By this means they have been able usually to lay aside large surpluses and often to distribute a part of the earnings to their employees in the form of bonuses or premiums, — all this in addition to substantial dividends to their stockholders.

On the other hand, how have the water-works finances fared under this unprecedented wave of prosperity? Occasionally we have received small increases in water revenue from speeded-up industries, which revenue seldom has offset the increased cost of service. The water-works business has been unable to meet the high costs because of its fixed rates which do not readily permit revision. The inflexibility of water rates renders us unable to adjust them to any rapid rise in the cost of our product.

With our inability to quickly readjust water rates under abnormal changes, what will be the remedy if costs are to continue as high as, if not higher than, at present? For water is still sold at the same old price, and in about the same quantities. The cost of water has not responded to the almost universal rise in prices. Water, that indispensable necessity, has not contributed to the high cost of living, for which a grateful public should be thankful.

To repeat, the water industry has been handicapped financially and otherwise by the inflated prices. If these new and abnormal conditions continue, or become in the future normal, then water works, whether public or private, must seek relief in increased rates if the public is to enjoy good service or if money is to be expended for new supplies, additions, and improvements.

Like nearly every one else, our Association has felt the effects of prevailing prices. Our dues and revenues have remained practically stationary, except for a considerable increase in income from entrance fees of new members. To offset this gain, printing, stationery, and sundries have kept step with high costs. If high prices are to be permanently established, this Association must consider ways and means of sound financing.

Speaking of our Association, what means this forced discussion

now going on? A well-known publication has taken upon itself the work of combining the two leading water-works associations of the country, with the belief that it would stop the loss of efficiency in them. The consequence of such combination would be the loss of this Association's identity and a prestige which has taken many years to build up. Evidently this magazine does not believe that "competition is the life of trade." Neither do I, when competition tends to hurt some one when that one is doing good. If there has been any competition between the American and the New England Water Works associations, it has always been friendly.

This publication says: "So long as old jealousies exist — and they will exist until the death of many of the older members — it is futile to talk consolidation." If that is a fact, why should this particular paper undertake at this time a campaign of consolidation? I firmly believe our old and active members have never been jealous of a sister organization. There is not now, and never has been, cause of envy. Many of our older members are or have been members of both organizations. Our members are not apprehensive of rivalship. Our members who belong to both, and those who have held office in both, have affection for both and are willing to sustain and defend both. Why this agitation for coalition? This year, like the preceding years, there has been neither discussion, agitation, nor any demand from within this Association for a merger or a subordination of its efforts or works to any other organization.

Why should this organization, at the height of its numerical strength and prosperity, wish to divide its success and its effective work? Why throw away our prestige and lose our unique position with the water-works interests of this continent? While it is true we may have a provincial name, our field of usefulness is as wide as the world.

Some of our members have been asked to express an opinion on the question of combination. Mark you, some of our members, not all. I do not know why not all. The replies from our active resident members have been timely, clear, and to the point. In substance, — no need to combine. I feel as if we should ignore this agitation. But I trust, as a loyal member, I have the right

to express my opinion that if a merger is necessary it will come about by proper and natural means and not through artificial channels.

The action of that magazine seems perilously near commercialism or exploitation. This campaign may have the effect of increasing circulation and furnishing advertisers with apparent proof of its influence. It looks like a hunt for new subscribers.

Did this publication know that its efforts were to create the impression that one organization was sufficient for the whole country or the world? And that it might have the effect that some members of both associations, believing that amalgamation was in sight, would fail to renew membership in one or the other? Or that prospective members of either Association might well wait and see what the outcome would be? Again, does this editor believe that manufacturers and supply men are unwilling to have " two shows " ? Has it really come to this, — that American enterprise has relegated the motto " No trouble to show goods " ? Or are the dealers so glutted with orders so far in advance that they do not want business? Do they think that the average water-works man should buy a " pig in a poke " ? In the last analysis, who should determine, if not dominate, the sale, — the buyer or the seller? It might be well for all, if the supply men would state whether this magazine speaks authoritatively. While combination and merging may be the solution of many industrial problems, the uniting of human nature and the personal elements as found in social and technical organizations is something not easily accomplished.

Large and unwieldy organizations are a failure in centralizing thought and good-fellowship. The elimination of duplicate organizations is not practical. Imagine only one political party! Why not merge all the colleges and schools and have the students come to one center? Weak publications may combine, but would it be well to combine the strong leading magazines into a trust and get only trust thoughts and policies? It seems to me we want freedom of thought and ideas, the individual opinion of writers and thinkers, and not over-organized thought that is " shrimped and iced."

For many years the principal water-works associations have

been doing splendid work for the water-works fraternity, each in its own way and field, but often working together in the same vineyard. This work is not completed, and never will be. These strong, vigorous organizations should retain their entities. They are necessary for water-works interests and useful to their members.

The New England Water Works Association has always had its place in the light, and its loyal members trust it will always remain there. Our organization is managed entirely by its members. Our members largely know one another. We are unique in the spirit of friendship and fraternal kindness. The large and regular attendance at our meetings and conventions proves this. Our permanent and fixed headquarters are of great value. They are not subject to rotation from place to place on account of a change of officers.

There is much sentiment surrounding our Association, for it has been the alma mater for many a practical water-works man. Many of our more fortunate members have had the advantage of technical education, and they are among our most loyal and active members. They have benefited by the rich experience of many a man who has come up from the trench. Our practical and our technical men have always worked in unison, have given of their time, experience, and talents. This free exchange of information and knowledge has been one of the big assets of this Association. Practical members have received from the technical members knowledge of their calling that they could not easily obtain in any other way. Is it not true that parts of even the most abstract technical paper stay with the practical men? These papers give him a general insight into subjects that pertain to his line of work. They broaden his vision and enlarge his vocabulary.

The practical water-works man may not be able to analyze water, yet nowadays he is able to intelligently interpret a report. He may not be able to make a culture and count the bacteria, nevertheless he knows in a general way the mysteries of such. He may not be able to tell the difference between typhoid and colon bacilli, but he has seen both illustrated on the screen. So it is about color, iron, manganese, filters, pump tests, etc. He has received a liberal education from membership in this Association, by hearing or reading the high-grade, practical, technical, theoreti-

cal, and research papers which have been presented. The practical papers have been logical, sound, and helpful.

Along with the practical and educational advantages of our Association, we have the social side. All these and more we get as members. Would we not miss something in our little world if we could not come to these congenial meetings or attend the pomp of our conventions? Have we not a rich heritage from our eminent members who have gone? They left the strong impress of their personalities; our organization is richer, and we honor and cherish their memory. To-day we have as members solid, substantial builders, men who do things; also brilliant, able, and forceful minds, all contributing to one another's education. I am confident our members value highly membership in this Association. If it is to merge or be merged, let it not be by exploitation. The proposition should be carefully considered. Personally, I do not believe in combination because we have no prospect of anything in return. If the time ever comes, our members will approach the matter with an open mind. In the meantime let it be known near and far that the New England Water Works Association will continue to pursue the course marked out for it many years ago, that we shall strive to continue past successes and in the future work for greater activity, both educationally and socially.

Mr. John C. Chase. Mr. President, I want to express myself in a few words as heartily and thoroughly in favor of the law as you have just laid it down. I think you are deserving of a vote of thanks from this Association. I think also the part of your report that refers particularly to the publication ought to be sent to them, that they may use it in their editorial columns if they please.

I don't know why I should be singled out to be honored, as you may term it, with an invitation to express an opinion. I have a little curiosity to know if the opinion I expressed to them was in print. I seriously have my doubts about it, because I expressed myself in no uncertain way, practically on the lines you have indicated, and furthermore, to the extent that if any merger was to take place it would be a merger into the New England Association.

Gentlemen, I want to move to you that a vote of thanks be given to the President of this Association for his presentation of this case.

There seems to be no Vice-President present. I will ask all those in favor of the motion to manifest it by rising.

(The motion was adopted by the Association.)

Election of Officers,

The tellers appointed to canvass ballots for officers for the coming year submitted the following report:

Whole number of ballots	377
Blanks, 1; unsigned	2

President.

Caleb M. Saville	355
Scattering	1

Vice-Presidents.

Carleton E. Davis	360
Samuel E. Killam	365
Henry V. Macksey	361
Frank A. Barbour	361
Percy R. Sanders	359
Thomas McKenzie	361
Scattering	2

Secretary.

Willard Kent	360

Treasurer.

Lewis M. Bancroft	364

Editor.

Richard K. Hale	364

Advertising Agent.

George A. King	366

Additional Members Executive Committee.

William F. Sullivan	361
Frank J. Gifford	362
A. R. Hathaway	359
Scattering	1

Finance Committee.

EDWARD D. ELDREDGE 362
A. E. PICKUP 362
BERTRAM BREWER 363

Respectfully submitted,

DAVID A. HEFFERNAN,
WM. J. LUMBERT,
FREDERIC I. WINSLOW,
Tellers.

THE PRESIDENT. You have heard the report of the committee appointed. These gentlemen named are the respective officers for the ensuing year.

In retiring from the office of President, I wish to thank all the members of the committees and officers for the faithful support they have given me. No one ever received more prompt support and assistance. I never called upon any one for assistance without immediate response. The best I ask for the incoming administration is that you show to them the same kindliness, loyalty, and friendship that you have shown to this administration. If you do, the incoming administration will go on and show greater success than we have shown this year. True, we have lifted the membership over 1,000, and I trust you will lift the membership over 1 100 this year. It is a big task you have got, Mr. Incoming President.

The incoming President is a man who has always taken a keen interest in the Association. He has contributed papers of great value. You all know him. And it gives me great pleasure to present to you the incoming President of the New England Water Works Association, Mr. Caleb Mills Saville.

Mr. Saville, the incoming President, then addressed the Association as follows:

INCOMING PRESIDENT'S ADDRESS.

Mr. President and Gentlemen, — In looking back over the long roll of efficient water-works men who have received from your hands the honor of being made President of the New England Water Works Association, it has been impressed upon me that

the duties of this position are not to be lightly undertaken if the high standard which has been set is to be maintained.

To follow in the footsteps of such men as Brackett, FitzGerald, Sedgwick, and others, makes this a distinction to be highly prized by water-works men.

No laurels, however, are worth while which can be had without effort, and as you have seen fit to honor me with this office, which I assure you I greatly appreciate, I undertake to do all that in me lies to forward the best interests of the New England Water Works Association.

Individual effort, rightly placed, will accomplish much, but constant coöperation of many minds and hands is irresistible. This is our association, — yours and mine; you, too, have a duty to perform, and one which as managers, superintendents, and engineers you owe not only to the water-works fraternity but to the public at large.

Into your hands is committed the most important of all public responsibilities, — the safeguarding of the nation's health. To do this honestly, efficiently, and economically is a man's work.

The precedents of this Association are replete with examples of the highest type of character as well as of efficiency and progress in water-works affairs.

On you rests the burden of maintaining the high standard of manhood that is our inheritance.

To be of the utmost value to us, individually, and to the community at large, we must remain true to our traditions and devote our energies to the water-works problems of the day. We are not selling goods for a material house; we are selling our knowledge of water-works matters to the public. If we would succeed in our own work we must not be swerved aside from our purpose either by Circean blandishments similar to those of the old-time commercial drummer or the Machiavellian machinations of the wily politician.

This society is called the New England Water Works Association, and the bulk of its members are dwellers in the northeastern section of this country. Its early formation was sectional, and its original purpose was only to enable local water-works men in New England to get together and talk, heart to heart, about the

special matters that perplexed them. The fame of its good work and high ideals spread, and other serious-minded men with like problems recognized its value and desired to be enrolled among its members, until now its membership is limited only by the confines of the world.

Its papers, its morale, its purpose, the conduct of its members and their meetings, have been such that earnest and thinking men are proud of their connection with this Association.

Its aim and object is to discuss and meet work conditions confronting water-works men and especially those problems which are of local significance. To do this effectively we can allow this Association neither to degenerate into a social club nor to entertain ambitions for power in national affairs.

" By their deeds shall ye know them," and by the conduct of our meetings will our Association gain or lose in public opinion. It is no more simple matter to serve two masters under work-a-day conditions than it is under the moral law. It is impossible to hold frivolous meetings and expect the public to believe we are a serious body, earnestly working for its welfare.

We must recognize that great good is being done by others working in the same field as ourselves, and it should be our desire to coöperate and extend to them and to the nation our help in every possible way. We must, however, bear carefully in mind the Washington advice, " to avoid entangling alliances."

We should cling to the precepts and examples of the fathers of this Association, and to the fundamental principles that have placed and held it in its present enviable position.

Our past record is secure, and plainly shows that we have found our " place in the sun." It must be our constant endeavor to hold it against every onslaught, no matter how insidious.

Up to the present we have held this place honorably, " with charity to all and with malice toward none." With your help, mine is the privilege and duty to retain this high estate and keep the faith with the founders and builders of this Association.

Gentlemen, I have great pleasure in wishing you all a happy and prosperous coming year.

On motion duly made, the Association voted to adjourn.

FEBRUARY MEETING.

HOTEL BRUNSWICK,
BOSTON, February 14, 1917.

Caleb M. Saville, President, in the chair.
The following members and guests were present:

HONORARY MEMBERS.

R. C. P. Coggeshall.
A. S. Glover.
F. E. Hall.
F. P. Stearns.
R. J. Thomas. — 5.

MEMBERS.

E. R. B. Allardice.
L. M. Bancroft.
H. K. Barrows.
G. W. Batchelder.
A. E. Blackmer.
J. W. Blackmer.
George Bowers.
Bertram Brewer.
James Burnie.
Eugene Carpenter.
George Cassell.
C. E. Chandler.
John C. Chase.
F. L. Cole.
F. W. Dean.
H. P. Eddy.
C. H. Eglee.
E. D. Eldredge.
R. H. Ellis.
F. F. Forbes.
Patrick Gear.
H. T. Gidley.
F. J. Gifford.
H. J. Goodale.
X. H. Goodnough.
P. T. Gray.
R. A. Hale.
R. K. Hale.
D. A. Hartwell.
A. R. Hathaway.
D. A. Heffernan.
A. C. Howes.
W. F. Howland.
A. W. Jepson.
W. S. Johnson.
Willard Kent.
G. A. King.
John Knickerbacker.
P. J. Lucey.
S. H. McKenzie.
Thomas McKenzie.
Hugh McLean.
H. V. Macksey.
E. H. Magoon.
A. E. Martin.
W. E. Maybury.
John Mayo.
F. E. Merrill.
G. F. Merrill.
H. A. Miller.
W. H. O'Brien.
J. W. O'Neill.
T. A. Peirce.
A. E. Pickup.
C. R. Preston.
L. C. Robinson.
G. A. Sampson
C. M. Saville.
A. L. Sawyer.
J. E. Sheldon.
G. H. Snell.
O. H. Starkweather.
J. F. Sullivan.
W. F. Sullivan.
C. N. Taylor.
Edwin A. Taylor.
L. D. Thorpe.
J. L. Tighe.
A. H. Tillson.
E. J. Titcomb.
D. N. Tower.
C. H. Tuttle.
C. L. Ward.
Percy Warren.
R. S. Weston.
F. E. Winsor.
I. S. Wood. — 77.

ASSOCIATES.

Allen & Reed, Inc., Z. M. Jenks.
Harold L. Bond Co., F. M. Bates.
Builders Iron Foundry, A. B. Coulters, F. N. Connet.
A. M. Byers Co., H. F. Fiske.
Chapman Valve Mfg. Co., V. N. Bengle, James Mulgrew.
Eddy Valve Co., H. R. Prescott.
Fire and Water Engineering, Fred Shepperd.
F. H. Hayes Machinery Co., F. H. Hayes.
Hersey Mfg. Co., J. H. Smith.
Ludlow Valve Mfg. Co., A. R. Taylor.
H. Mueller Mfg. Co., G. A. Caldwell.
National Meter Co., H. L. Weston, J. G. Lufkin.
Neptune Meter Co., H. H. Kinsey, R. D. Wertz.
Pittsburgh Meter Co., J. W. Turner.
Rensselaer Valve Co., C. L. Brown.
A. P. Smith Mfg. Co., F. L. Northrop.
Standard Cast Iron Pipe and Foundry Co., W. F. Woodburn.
Thomson Meter Co., E. M. Shedd.
Union Water Meter Co., D. K. Otis.
R. D. Wood & Co., H. M. Simons.
Henry R. Worthington, W. F. Bird, Samuel Harrison. — 26.

GUESTS.

MAINE.

Auburn, A. W. P. Cobb.

MASSACHUSETTS.

Brookline, D. Lacy, forester.
Chicopee, J. J. Page, Edward L. Frazier, water commissioners.
Cohasset, Dr. O. H. Howe.
Holyoke, C. C. Coyne.
Monument Beach, Theodore Chaffin, superintendent water works.
Somerville, William Myers.

RHODE ISLAND.

Providence, M. H. Bronsdon, city engineer; John Kelso, commissioner.

CONNECTICUT.

Bristol, C. L. Wooding, commissioner.
Norwich, C. B. Palmer, civil engineer.
New Haven, Prof. J. W. Toumey, director School of Forestry, Yale College.

PENNSYLVANIA.

Philadelphia, F. A. Frank. — 14.

Applications for membership, properly endorsed and recommended by the Executive Committee, were presented by the Secretary as follows:

Resident — E. C. Wardwell, Waterville, Me., trustee Kennebec Water District; W. R. Ellis, Danielson, Conn., superintendent of local water works; Frederick A. Cole, Newtonville, Mass., engineer of water-works construction.

Non-Resident — Charles L. McNeil, Torrington, Conn., secretary and treasurer Torrington Water Company; John C. Ford,

Woodbury, N. J., superintendent Water Works; George F. Drew, Brunswick, Me., mill engineering.

On motion of Mr. Lewis M. Bancroft, the Secretary was instructed to cast one ballot in favor of the applicants named, and he having done so they were declared duly elected members of the Association.

Mr. Frank Winsor, chief engineer Water Supply Board, city of Providence, R. I., gave an illustrated talk on the new water supply for that city. Mr. Frederic P. Stearns, consulting engineer; John. Kelso, member of the Providence Water Board; Milton H. Bronsdon, city engineer, and Irving S. Wood, assistant city engineer in charge of the Water Department, Providence, also spoke.

Prof. J. W. Toumey, director School of Forestry, Yale College, New Haven, Conn., gave an address on " Forestry in Relation to Public Water Supplies." The subject was discussed by Mr. John Kelso, Providence Water Supply Board; Hiram A. Miller and Elliot R. B. Allardice, who spoke of the forestry work in connection with the Metropolitan Water Supply; William F. Sullivan, engineer and superintendent, Nashua, N. H.; Patrick Gear, superintendent, Holyoke; and Frank Winsor, chief engineer Water Supply Board, Providence, R. I.

Adjourned.

EXECUTIVE COMMITTEE.

Meeting of the Executive Committee of the New England Water Works Association, December 13, 1916, at headquarters, Tremont Temple, at 11 A.M.

Present: President William F. Sullivan, and members Caleb M. Saville, Samuel E. Killam, D. A. Heffernan, R. C. P. Coggeshall, F. J. Gifford, Willard Kent, Richard K. Hale, Lewis M. Bancroft, and George A. King.

Five applications for membership were received, viz., Charles L. Crosier, assistant in civil engineering at Mass. Inst. of Technology, 316 Huntington Avenue, Boston, Mass.; Richard H. Ellis, superintendent Board of Public Works, North Andover, Mass.; James Menzies, superintendent Water Works, 387 George Street, Sydney, N. S.; Ernest H. Rigg, chairman of Water Committee, City Council, 132 Horace Street, Woodbury, N. J.; Thorndike Saville, assistant in municipal administration, Harvard University, 5 Sumner Road, Cambridge, Mass., and the several applicants were unanimously recommended therefor.

Chairman King, of the subcommittee on increase of revenue, reports suggesting that this committee advise that the attention of the incoming Executive Committee be called to the need of increasing the advertisements in the JOURNAL, and that the individual members of the committee may help this by personal solicitation; for the purpose of increasing the value of the advertisements to our patrons, that personal items and news items be incorporated among the advertisements; that there be an additional day given for the Annual Convention, this day to be for the use of the exhibitors, the day not to be either the first or the last day of the Convention.

Mr. George A. King, Mr. Caleb M. Saville, and Mr. Carleton E. Davis were made a committee to consider amendment to Constitution with reference to membership dues.

On motion of the Advertising Agent, Mr. George A. King, the

President was authorized to appoint a committee to consider the question of Advertising Agent's compensation. Messrs. Caleb M. Saville, Richard K. Hale, Samuel E. Killam, Lewis M. Bancroft, and Frank J. Gifford were made that committee.

Adjourned.

Attest: WILLARD KENT, *Secretary.*

Meeting of the Executive Committee of the New England Water Works Association at headquarters, Tremont Temple, Boston, January 10, 1917.

Present: President William F. Sullivan, and members Caleb M. Saville, Carleton E. Davis, Samuel E. Killam, D. A. Heffernan, Robert J. Thomas, F. J. Gifford, Richard K. Hale, Lewis M. Bancroft, George A. King, and Willard Kent.

The following applications for membership were received and recommended therefor: Dudley Chipley, engineer and superintendent Water Works, Columbus, Ga.; William H. O'Brien, foreman Chicopee Water Department, 193 Hampden Street, Chicopee, Mass.; C. Ashley Stevens, water commissioner, Cummington, Mass.; John F. Sullivan, superintendent Chicopee Water Department, 109 Church Street, Chicopee Falls, Mass.

Messrs. Frederic P. Stearns, M. N. Baker, and A. E. Martin were by unanimous vote constituted a committee to recommend the award of the Dexter Brackett Memorial Medal for the year 1916.

Mr. W. S. Johnson, chairman of the Committee of Arrangements for the Annual Convention of 1916, presented the report of that committee, which was accepted and the recommendation that the Annual Convention of the Association in future be of four days' duration instead of three and that the Treasurer of the Association be *ex officio* a member of, and treasurer for, all committees of the Association controlling the expenditure of money, was by unanimous vote endorsed by the Executive Committee.

Voted: That the subject of the Water Works Manufacturers' Association's contribution to the expenses of the Annual Convention be referred to the Executive Committee of 1917.

President Sullivan presented a report for the Executive Committee, and by unanimous vote it was adopted as the report of the committee.

Adjourned.

Attest: WILLARD KENT, *Secretary.*

Meeting of the Executive Committee of the New England Water Works Association, January 29, 1917, at headquarters, Tremont Temple, pursuant to call of the President.

Present: President Caleb M. Saville, and members Samuel E. Killam, Henry V. Macksey, Percy R. Sanders, Frank J. Gifford, Willard Kent, Richard K. Hale, Lewis M. Bancroft, and George A. King.

The resignation of Mr. E. C. Sherman from the Committee on Furniture, on account of absence, was received and his duties on that committee were delegated to Mr. Killam.

The continuation certificate of the Treasurer's bond for five thousand dollars in the Massachusetts Bonding and Insurance Company, of Boston, Mass., from January 12, 1917, to January 12, 1918, was presented and by unanimous vote approved.

The resignation of Mr. Frederic P. Stearns from the Committee of Award of the Dexter Brackett Memorial Medal for 1916 was received, and on motion of Mr. Macksey, seconded by Mr. Bancroft, was accepted, and Mr. Desmond FitzGerald was elected to fill the vacancy on that committee.

After a general discussion of arrangements for the Annual Convention, the meeting was adjourned.

Attest: WILLARD KENT, *Secretary.*

Meeting of the Executive Committee of the New England Water Works Association at headquarters, Tremont Temple, Boston, Wednesday, February 14, 1917, at 11.00 A.M.

Present: President Caleb M. Saville, Henry V. Macksey, Thomas McKenzie, William F. Sullivan, Frank J. Gifford, A. R. Hathaway, Richard K. Hale, Lewis M. Bancroft, George A. King, and Willard Kent.

Six applications were recommended, and the several applicants were by unanimous vote recommended for membership in the Association, viz.: Frederick A. Cole, engineer of water-works construction, Newtonville, Mass.; George F. Drew, resident engineer, Brunswick, Me.; W. R. Ellis, superintendent of local water works, Danielson, Conn.; John C. Ford, superintendent Water Department, Woodbury, N. J.; Charles L. McNeil, secretary and treasurer Torrington Water Co., Torrington, Conn.; and E. C. Wardwell, trustee Kennebec Water District, Waterville, Me.

Messrs. Hugh McLean, J. E. Sheldon, Charles C. Coyne, secretary Chamber of Commerce, of Holyoke, and A. S. Glover, W. S. Johnson, and R. C. P. Coggeshall were present by invitation, and matters pertaining to the annual convention were discussed.

Adjourned.

Attest: WILLARD KENT, *Secretary.*

WATER-WORKS NOTES.

It is planned to publish, in the advertising pages of the JOURNAL, notes in regard to water-works matters which appear to be of interest to the membership. It is hoped that Members and Associates will assist by sending in short accounts of what they are doing in the water-works field that will be of general interest. These notes should reach the Editor by the 15th of May in order to appear in the June JOURNAL.

The Brunswick and Topsham Water District (Chas. L. Bowker, superintendent) has installed an electric motor-driven centrifugal pump, on trial, to pump from driven wells.

Pump was started December 18, 1916, and has been used continually since. Some changes will probably be made before everything is in good working order and a test made to determine cost of pumping and the real capacity of the pump.

Consumption of water in this District is around 500 000 gallons a day.

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Water Meters

FOR ALL WATER WORKS SERVICE

All Sizes, 5-8 to 60 inches

CROWN

EMPIRE

NASH

GEM

PREMIER

With the only reliable straight-reading register in the market

National Meter Company

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BOSTON	CHICAGO	PITTSBURG	LOS ANGELES
159 Franklin St.	1223 Wabash Ave.	4 Smithfield St.	411 So. Main St.
	CINCINNATI	SAN FRANCISCO	
	10 West Third St.	681 Market St.	

The NASH
GAS ENGINE and TRIPLEX PUMP

FOR
Town and Village Water Works and Pumping Service Generally

CAN BE ADAPTED FOR EITHER GAS OR GASOLENE

National Meter Company
84-86 CHAMBERS STREET, NEW YORK

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PITTSBURG: 4 Smithfield Street
CINCINNATI: 10 West Third Street
CHICAGO: 1223 Wabash Ave.
SAN FRANCISCO: 681 Market Street
LOS ANGELES: 411 South Main Street

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HERSEY DETECTOR METER

The Hersey Detector Meter has been accepted for eleven years in 3", 4", 6", 8", 10" and 12" sizes without any restrictions or conditions of any kind by every Insurance Company, Stock and Mutual, doing business in the United States, and by the Water Departments and Water Companies in more than 500 Cities and Towns for use on over 3,000 Fire Services protecting nearly $2,000,000,000. worth of Insured Property.

HERSEY MANUFACTURING COMPANY

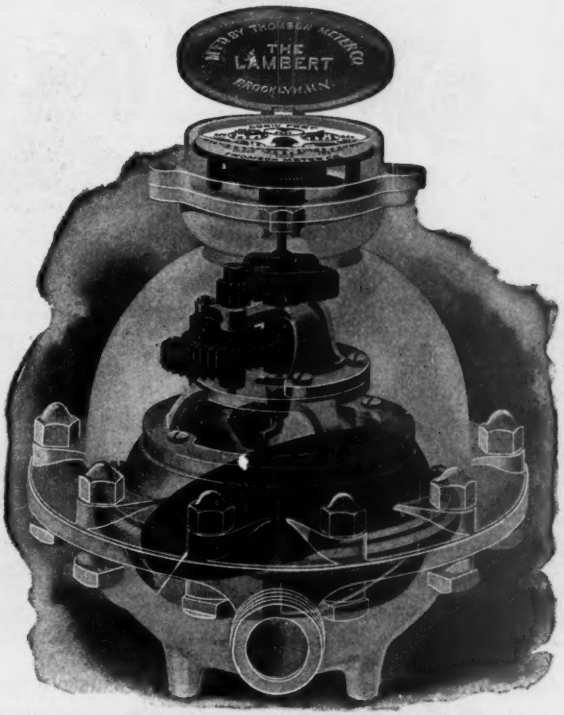
BOSTON	COLUMBUS, O.	SAN FRANCISCO
NEW YORK	PHILADELPHIA	LOS ANGELES
CHICAGO	ATLANTA	PORTLAND, ORE.

ACCURACY, LONG LIFE,

Avoidance of Repairs

Are the Requisites of the Perfect Water Meter and are the Principal Features of the

"LAMBERT."



Our unbreakable disk-piston, reinforced with an internal steel plate, can be found only in the **LAMBERT METER.**

The growing popularity of the water-meter system is attributed by many to the inherent excellence of the **"LAMBERT"** meter. Where **"LAMBERT"** meters are selected, success is assured.

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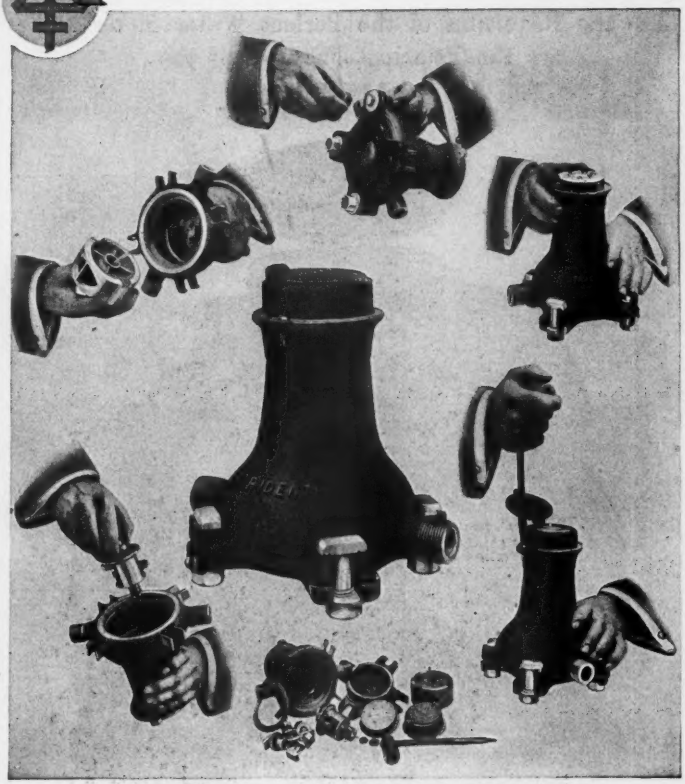
BROOKLYN, N. Y.

TRIDENT WATER METERS



Assembling Simplicity of Trident Construction

The above cut shows a Trident-Disk Meter dismantled and the extreme ease with which it can be assembled, by first putting in the gear train, then the disk-chamber, the frost bottom next, then the register and register box and the meter is complete. The Trident combination wrench is the only tool necessary to use.

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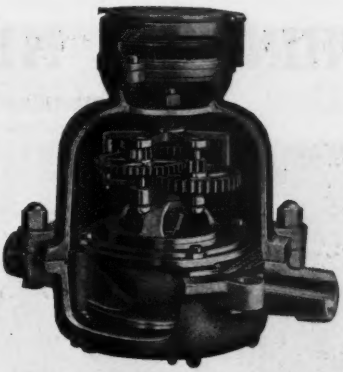

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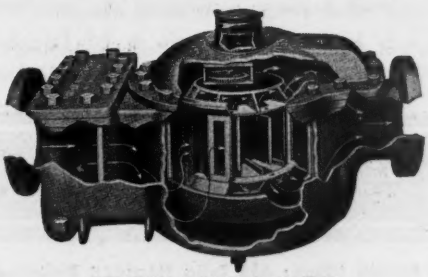
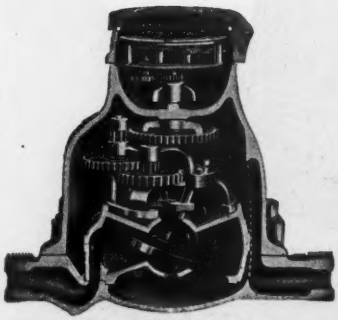
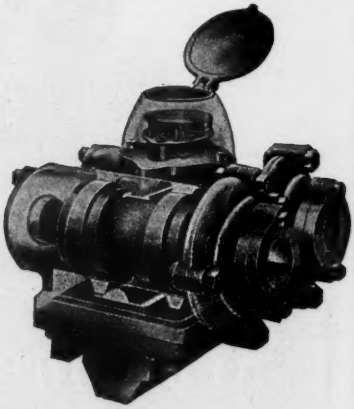


"EUREKA" WATER METER

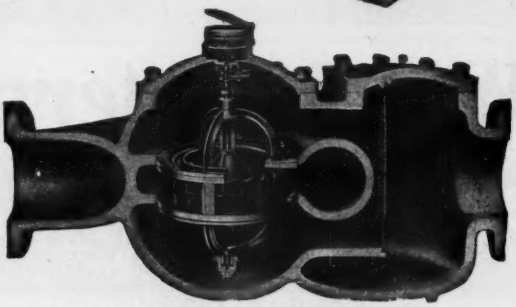
WORTHINGTON METERS

The Worthington Duplex Piston Meter is particularly adapted to large and heavy water works services.





The Worthington Disc Meter combines minimum weight with reliability on constant service accuracy of registration.



The Worthington Turbine Meter
is designed primarily to handle large volumes of water with minimum loss of pressure.

Full descriptions of the different types of Worthington Meters, with tables of sizes and capacities, are given in Bulletin W184–54.

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WATER-WORKS NOTES (*Continued*).

Nicholas S. Hill, Jr., and S. F. Ferguson are the consulting engineers for the New York and New Jersey Water Company, and are now designing for them a new 30-in. cast-iron pipe line across the New Jersey Meadows and reconstructing the present steel pipe line, which is to be placed on pile and concrete piers. One of the interesting features of this work will be a tunnel to carry two 30-in. cast-iron pipe lines under the yards and main line of the Pennsylvania Railroad near the Manhattan Transfer Station, also the D. L. & W. tracks, there being a total of about thirty railroad tracks under which these mains will pass. It will be necessary to carry on this work without in any way interfering with the heavy and frequent traffic of these railroads.

They are also engaged as consulting engineers by the city of Birmingham, Ala., in valuating the water-works plant in that city which is owned by the Birmingham Water Company and which is controlled by the American Water Works and Electric Company.

(*Continued on page xix.*)

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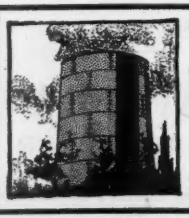

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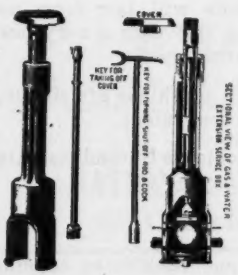

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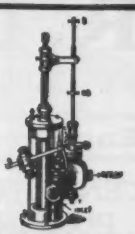

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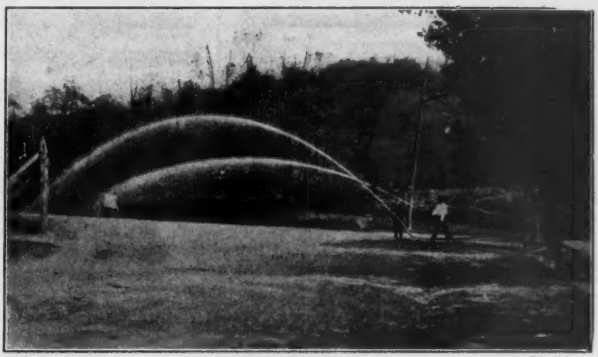

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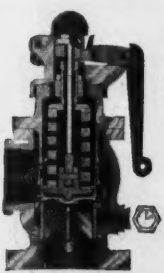

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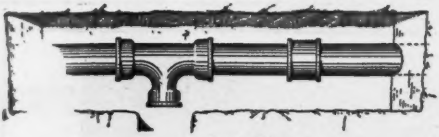
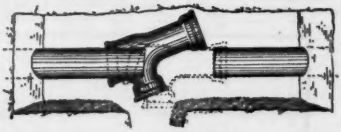
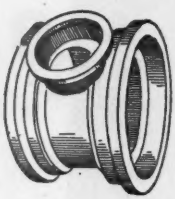


Old Way



Our Way



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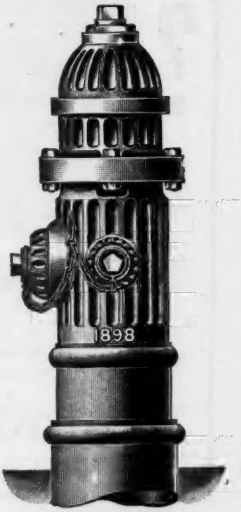

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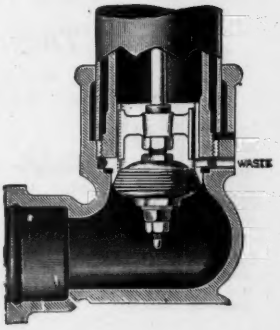

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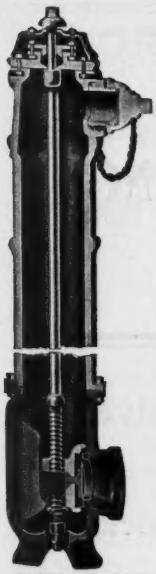

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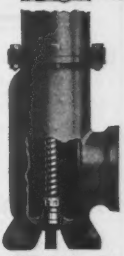

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The Vivian Rate Controller
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WATER-WORKS NOTES (*Continued*).

As consulting engineers to the Consolidated Water Company of Suburban New York, Hill & Ferguson have recently completed the design and are now supervising the construction of work incident to raising the dam at their Pocantico Reservoir in Westchester County, New York. This dam is an earth structure with masonry core wall, and by placing the new concrete core wall on top of this old one and making the new fill on the downstream side of the old dam and behind the new core wall, it has been possible to raise the dam eight feet without unwatering the reservoir. The capacity of the reservoir has been increased from 37.8 million to 90 million gallons. Eight large hand-operated sluice gates are provided in the new concrete spillway section, the area of these gates being sufficient to handle a maximum flood, preventing flooding of adjacent property.

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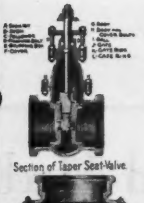
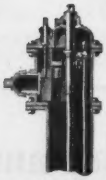
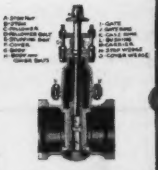


Section of Taper Seat-Valve.



Hydrant with Independent Nozzle Cutoff.



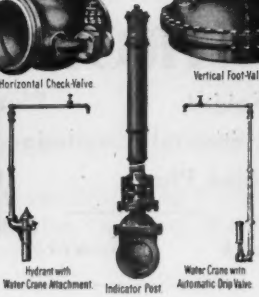
Section of Parallel Seat-Valve.

Section of Vertical Check-Valve.

Section of Vertical Foot-Valve.

Horizontal Check-Valve.

Vertical Foot-Valve.



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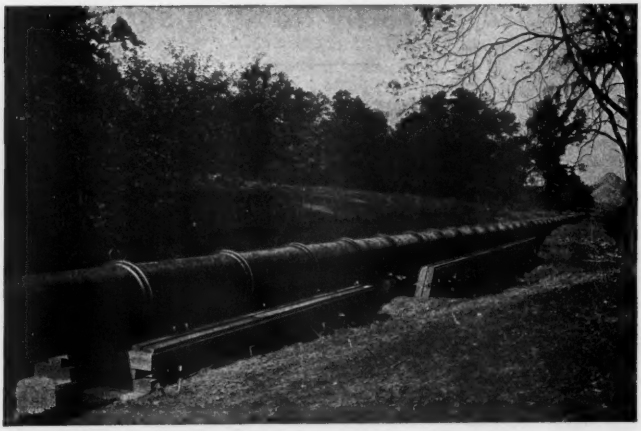

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.....

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JUNE 1917

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